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Engineering and Mining Journal

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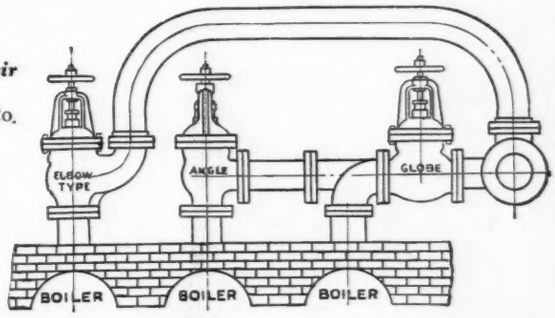

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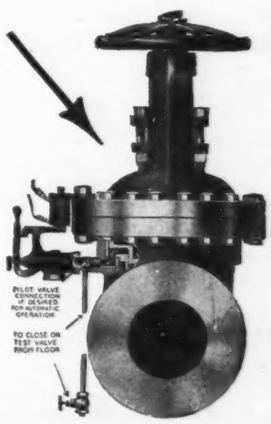

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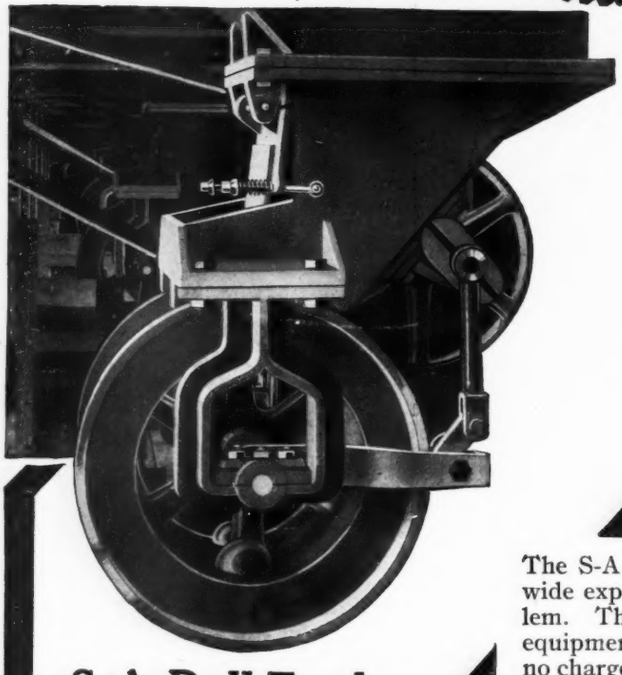

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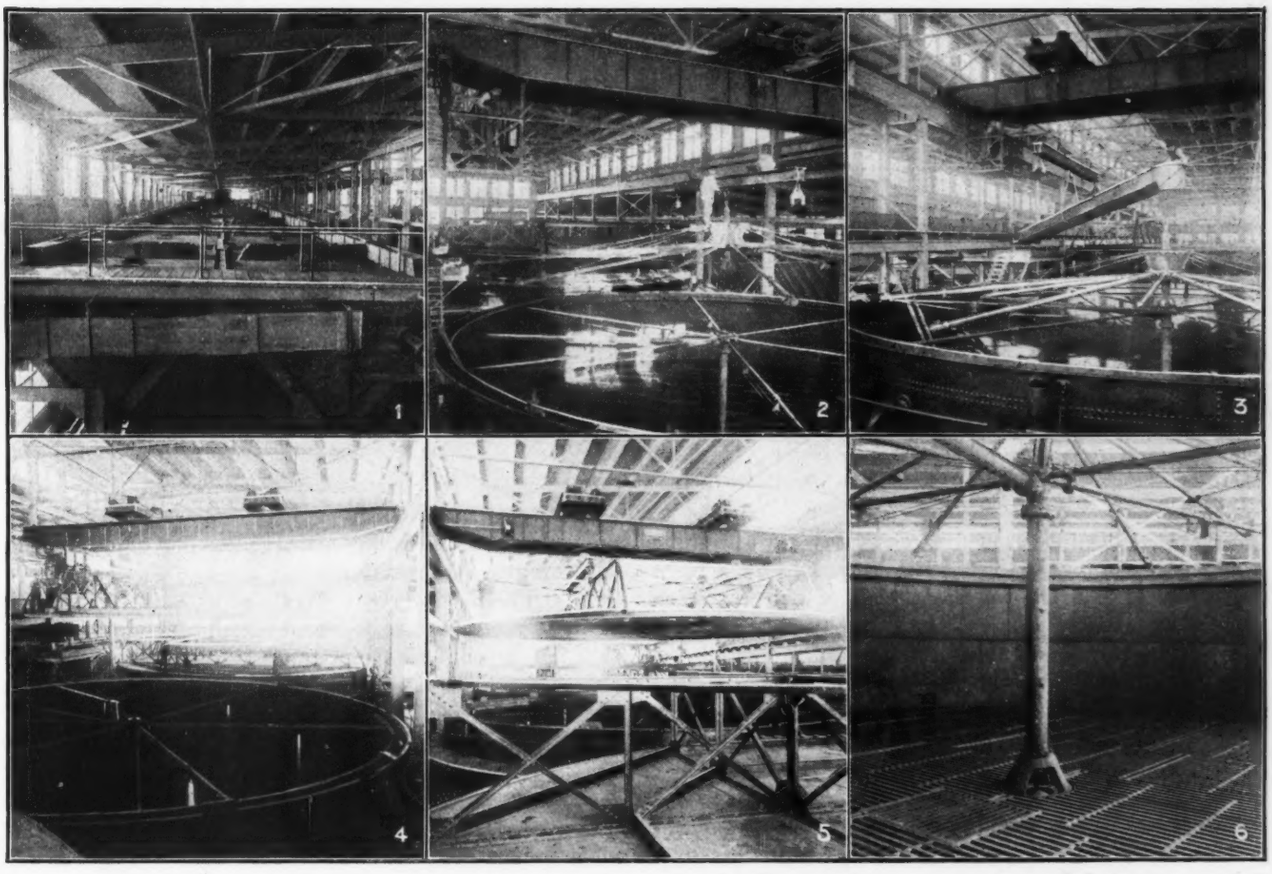
Ammonia Leaching of Calumet Tailings

By C. HARRY BENEDICT
Metallurgist for the Calumet & Hecla Mining Co.

The ammonia leaching plant of the Calumet & Hecla Mining Co. is probably the first large-scale installation of its kind. It is handling 2000 tons per day of sands, recovering an average of about 75% of the copper content at a cost of about 6c. per lb. of copper sold.

THE ammonia leaching plant of the Calumet & Hecla Mining Co. went into commission on a limited scale in July of last year. By February of this year the entire plant of 2000 tons daily capacity was finished, and at present the foundations are in for doubling it. There have been no difficulties of any kind in starting the plant, and one sand tank after another was put into commission as quickly as the construction work on it was finished. So far as I know, this is the first example of the successful commercial operation of an ammonia leaching process, and its apparent simplicity in operation has been such as to make it difficult to understand why such a method, or a similar one, had not been devised years before. As far back as 1871, in discussing a paper before the American Institute of Mining Engineers, the matter of the native copper losses in Calumet & Hecla tailings was taken up and the fact was brought out by a Mr. McFarlane that this copper, in the fines at least, could be almost completely dissolved in solutions of ammonium salts. The matter was evidently not followed up, although there were some investigators in the field, and in 1904 a



INTERIOR VIEWS OF THE CALUMET & HECLA AMMONIA LEACHING PLANT, LAKE LINDEN, MICHIGAN

Fig. 1—Settling tanks
Fig. 2—Crane handling the distributor
Fig. 3—Distributor in place, portable launder being adjusted
Fig. 4—Solution inflow
Fig. 5—Crane handling the tank cones
Fig. 6—Inside of tank, showing filter grating on the bottom and the central standard for the distributor

patent was issued to Ernest A. LeSueur, of Ottawa, for an ammonia process, and in his patent description he mentioned the Calumet & Hecla sands. This patent was called to my attention about ten years ago, and Mr. LeSueur and myself did a little work on the matter; and while it was evident that it was easy to get the copper into solution, we were not able to hit upon any method that seemed feasible for getting back the copper after once it was dissolved.

The matter was dropped entirely until the fall of 1912. At this time, having occasion to familiarize myself with the distillation of ammonia products, the idea occurred to me of using this method of recovering copper from solution. A test of the process on a laboratory scale at once gave great promise, and it was not long before a one-ton plant was in operation. This plant only tended to confirm results obtained on a smaller scale, and the next step was to build a 20-ton plant. This too, proved successful and while there were many points that could not be proved in a plant of this size, still the apparent cost of the operation was so low and the margin of profit indicated so large that we felt we could take a chance on many of the doubtful factors and begin the construction of the full-sized plant. The decision to go ahead with this work was made in the spring of 1914, and the contracts for much of it had been let when the European War broke out. The unsettled condition of affairs caused the company to cancel these contracts, and it was not until toward the end of the year 1914 that we had sufficient financial courage to go ahead. Work was begun in earnest in the spring of 1915, and thanks to good deliveries of material, the plant was in partial operation within 15 months of the time ground was broken for the foundations.

Before giving a detailed account of the process as finally applied, it may be well to give briefly some of the chemistry of the process. Oxide of copper or native copper with the free access of air, dissolves in ammonium carbonate to form cupric ammonium carbonate, probably according to the following reactions:

$$Cu + O = CuO$$

$$CuO + (NH_4)_2CO_3 = CuCO_3 . 2NH_3 + H_2O$$

This cupric ammonium carbonate, in the presence of native copper and without free access of air, is reduced to the cuprous state as follows:

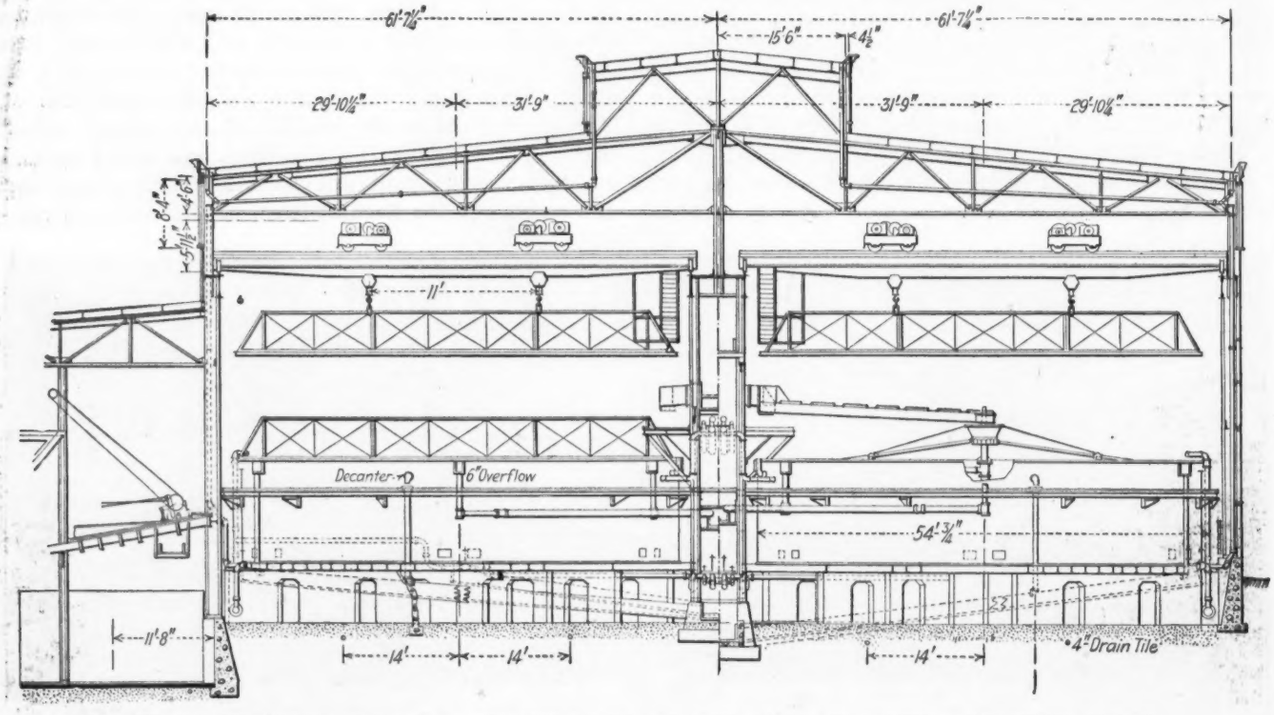
$$CuCO_3 . 2NH_3 + Cu = Cu_2CO_3 . 2NH_3$$

The cuprous ammonium carbonate in the presence of air oxidizes rapidly to the cupric state, and as such is capable of dissolving a further amount of copper. Now either the cuprous or cupric ammonium carbonate, when subjected to boiling or distillation with steam, loses its ammonia and carbonic-acid gas, both of which can be absorbed in water and recovered, and as these are driven off, the cuprous or cupric oxide is thrown out of solution either as a heavy powder or as a scale, according to this reaction:

$$CuCO_3 . 2NH_3 + H_2O + \text{Heat} = CuO + (NH_4)_2CO_3$$

If these reactions are followed through, it will be found that the solvents are quantitatively regenerated and that the only consumption of a chemical element is that of oxygen from the air. Not only is this theoretically the case, but it was demonstrated in the experimental work on Calumet conglomerate ore that these reactions did take place about as indicated and it was possible to make a recovery in the laboratory of practically 100% of the ammonia. This was done, however, by heating the tailings after the copper had been dissolved and the sand washed—an operation which of course is impracticable. The amount of ammonia remaining in the tailings before heating was small enough to assure the economic possibilities of the process.

It will be observed from the reactions that the solvent is cupric ammonium carbonate and that this is reduced

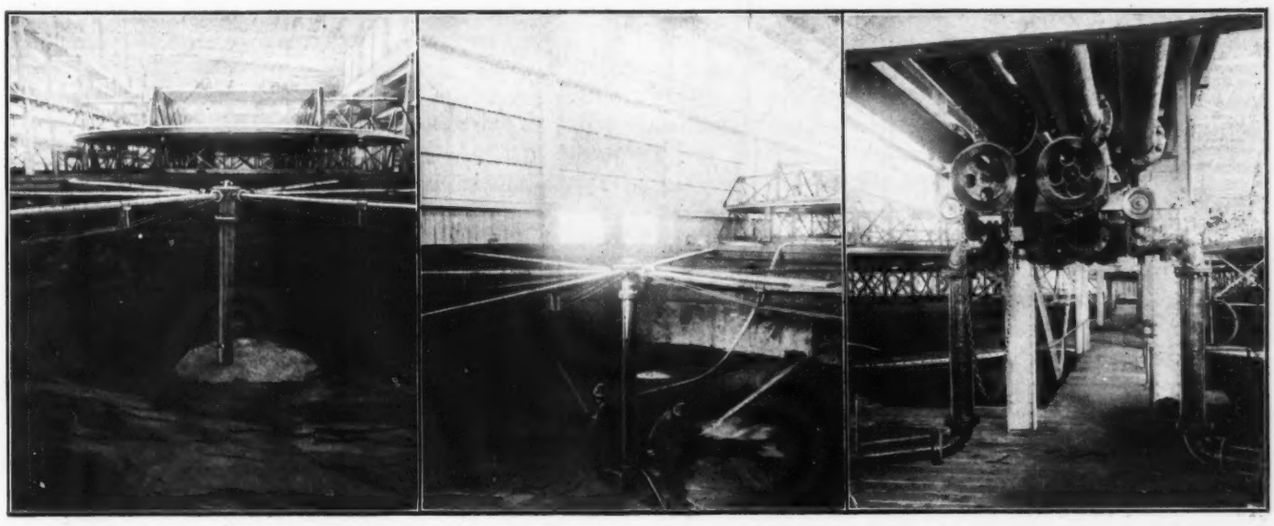


SECTION SHOWING THE TANK ARRANGEMENT OF THE CALUMET & HECLA REACTING PLANT

to the cuprous state in dissolving the native copper. To reoxidize this solution and restore its solvent power, only oxygen of the air is used, and the success or failure of the process depends upon the ability to oxidize the solutions quickly and without loss of ammonia. It is impossible to work entirely in inclosed vessels because to do that would prevent oxidation, and on the other hand to work entirely in open tanks is impractical not only because of the smell and discomfort, but also because it is almost sure to result in excessive loss of ammonia from volatilization. In working with a single tank, as was done in the experimental plant, it is easy to get sufficient oxidation of the solution by superficial action in the storage tanks, for the cuprous solutions have a great avidity for oxygen, and since the cupric salt formed is heavier than the cuprous, convection currents are set up that aid materially in the complete oxidation of the cuprous solutions. It was realized that in a large plant where the effluent solution from one tank would be in storage for only a limited time before being used again as a leaching solution, there would be much less opportunity for oxidation. However, this was worked out as the size of the plant increased, and we have found it a simple matter to oxidize the leaching solutions by blowing air through them and to absorb what little ammonia gas is driven off with the air in a wash solution. This particular feature, which caused the most concern in experimental work, was thus easily met as the plant developed.

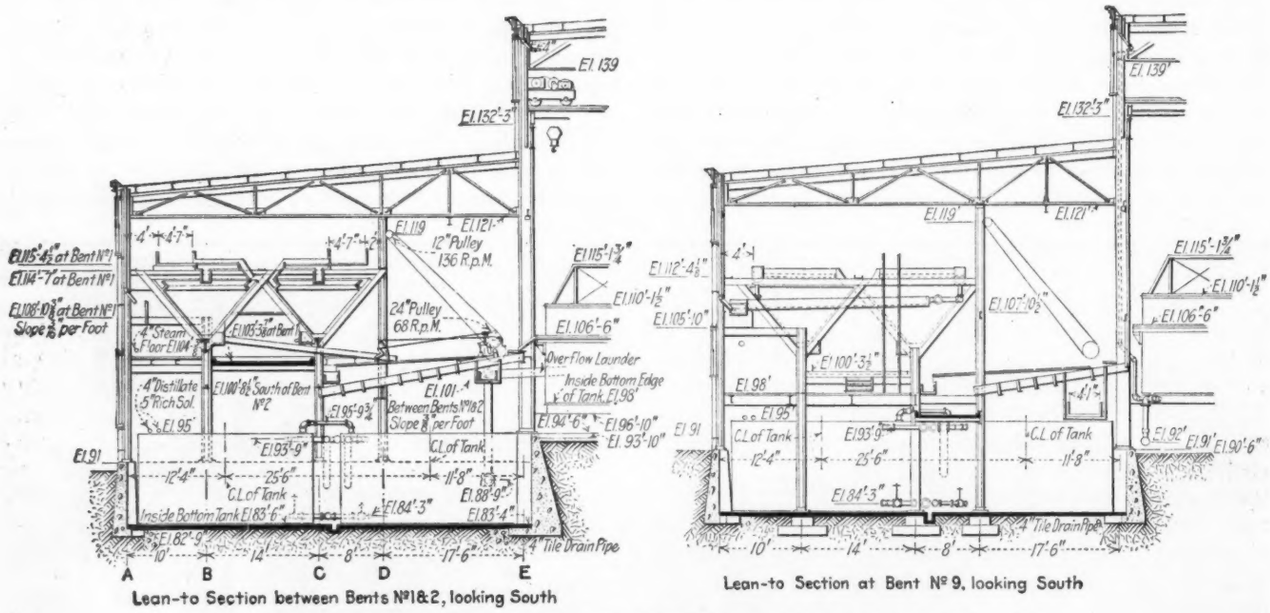
The other matter that caused a good deal of difficulty in the experimental work was the boiling-out of the solution. The oxide of copper as it was thrown down in the laboratory was a very fine powder which settled rapidly. It was hoped that on a large scale this powder might stay in suspension with sufficient agitation and then settle into a pocket and be easily removed by means of a trap discharge. What was actually found, however, was that while a part of the oxide could be handled by the foregoing methods, that part of it which had an opportunity of becoming superheated, as it would above the solution level, formed a scale so hard that it could be removed with nothing short of a hammer and chisel. It became evident that in order to distill this copper ammonium carbonate continuously would require a type of still different from anything on the market, and we set about making our own apparatus. We started out with a still consisting of twelve cylindrical sections, each 15 in. in diameter and 4 in. high and with a vertical shaft extending the full length of the still, fitted with a scraper for each section. The general principle of operation was similar to that of any continuous still, the solution passing downward from section to section against the ascending current of steam. This apparatus demonstrated that any scale of copper oxide formed could be handled by means of these scrapers, and a second still, 36 in. in diameter, was built, followed by the present commercial stills 84 in. in diameter. They have a capacity of over 150 cu.m. per day of copper ammonium carbonate solution assaying about 20 grams NH_3 per liter, and the same in copper.

The material treated in the present leaching plant consists of mill tailings as free from copper as the mechanical processes and water concentration will permit. A part of the material comes from the current tailings from the mine rock and a part of it from corresponding tailings that have been in Torch Lake for many years. No matter what the source, this material had been originally put through $\frac{3}{16}$-in. screens in a steam stamp and is now further ground in pebble mills to pass a 28-mesh screen. This product is then concentrated upon Wilfley tables, and it is the tailings from these tables that enter the leaching plant. In this leaching plant the feed, or heading, is lead to 16 V-shaped settling tanks, each 19½ ft. long, 10½ ft. wide and 6½ ft. deep. The overflow from these settling tanks contains practically all minus 200-mesh material and is at present a waste product, although plans are under way to treat it by flotation. The thickened product from these V-tanks is drawn off by means of plugs and led to eight quadruplex Dorr classifiers, the slimes from which go to waste and the sands to leaching tanks. This classified product is an ideal one for leaching, and while it carries some slimes, it has not been found necessary to observe any of the precautions sometimes taken in sand-leaching processes for eliminating all traces of colloids. There seems to be no serious obstruction to a satisfactory leaching rate.



SAND TANK PARTIALLY FLUSHED COMPLETION OF SAND FLUSHING SOLUTION PIPING AND VALVES

The leaching tanks in the present building are eight in number and arranged in two rows. Above each row there is an 18-ton traveling crane. The tanks are of steel, 54 ft. in diameter and 12 ft. high, and are provided with removable covers. The joint between the cover and the tank is water-sealed and is made by a channel on the cover projecting into a water-filled annular launder. The covers are supported by the sides of the tanks themselves, and there is sufficient headroom over the tanks to permit three covers being piled one on top of the other so that the crane can move the distributor or cover over a tank which is covered and which has upon it the cover of an adjoining tank. There is but one outlet for solutions, and that is in the bottom of the tank, near the center. On the inside of the tank at the top is the overflow launder, from which there are six outlets. This launder, during the leaching process, has its outlets plugged and is used to form the water seal for the cover, as already indicated.



DETAILS OF ARRANGEMENT OF THE CALUMET & HECLA LEACHING PLANT

In order to drain the water rapidly from the sand after filling, there are provided two 6-in. decanter pipes. There are seven discharging doors for sands in each tank, six along the sides at the bottom and one in the bottom at the center. The center gate is operated from above by means of a rod that extends up through the center column of the tank. The center column acts also as a support for the sands distributor, of the Butters and Mein type, which cannot be hung from above, as in the usual leaching tank, because of the clearance necessary for the cover. These leaching tanks are carried on 12-in. I-beams which in turn rest on concrete cross-walls of sufficient height to permit ready access to and inspection of all parts of the bottom. The tanks are provided also with a platform or runway 3½ ft. below the top, which forms the main working floor.

The method of distributing the sands is of interest. The main distributing launder runs the length of the building, and in the center between each set of four tanks discharges into a distributing box that can be closed off by means of a tipple. This tipple is pivoted at the low point of the launder and is capable of being raised and lowered. Each distributor box is fitted with four outlets which are in turn provided with rubber-gasketed cast-iron gates. The gates, when open, permit the discharge of material into a portable launder extending from the distributor box to the hopper of the tank distributor. By means of the tipple already mentioned, and the two distributor boxes with their four gates each, it is possible to divert the feed to any tank.

For supporting the sands in the tanks a filter grating of wood is provided, and a filter consisting of a lower layer of coco matting over which is 8-oz. duck. The coco matting and the duck are held in place by calking them with hemp ropes into grooves around the center gate casting and also around the periphery of the tank. After a year of use the first set of filter cloths and matting are still in commission and show no great evidence of wear. The details of these filters are similar to those used at the Homestake Mining Co., at Lead, S. D., and we are indebted to Allen J. Clark, of that company, for their design, which has proved eminently satisfactory.

For storing the leaching solutions and the wash there are at present 18 steel tanks, 22 ft. in diameter and 11 ft. high. For storing the concentrated solution of ammonium carbonate, as purchased or distilled, there are steel tanks with a total capacity of about 200 cu.m. In addition to this, there is a mixing tank 16 ft. in diameter and 1 ft. in height, in which one of the leaching solutions is made up to strength, and also constant-level tanks at the highest point of the building so as to give gravity flow under a constant head.

There are four ongoing solutions as follows: First leach, second leach, first wash and second, or water wash. There are four corresponding effluent solutions: Rich solution for distillation, new first leach, new second leach and new first wash. The rich solution, first leach and the ongoing second leach will all assay about 20 grams NH_3 per liter, with copper content respectively of about 18 grams, 12 grams and 9 grams per liter. These assays are subject to some change,

depending upon the copper content of the sands and upon the exigencies of operating conditions. The process is controlled by analysis of the copper and ammonia in the leaching solutions, and the aim is to keep these constant. To do this requires vigilance and necessitates regenerating by distillation a volume of solution containing copper equivalent to the amount extracted from the sands.

The general operation is as follows: The sands, as they leave the Dorr classifiers, are diluted with about four times their weight of water and run into the sand tanks through the distributor until the charge has reached the desired height. During this operation the excess water overflows from the tank, and the launders are so arranged that the bulk of this water can go back to the discharge of the Dorr machines as conveying water. When the tank is full, the water is drained off as rapidly as possible by means of the decanter. With the aid of a valve in the solution-outlet pipe, discharging to waste, the sands are drained until the surface is firm enough to work on. As the water goes down, any irregularities of the surface are evened up by poking the sand with sticks, which tends to break up all ridges and has no harmful effect upon the rate or uniformity of percolation. What little slimes are left remain on top of the settled surface as a very thin film, and this is broken up by means of a garden rake. The decanter-pipe covers are again put on, likewise the plugs in the overflow pipes, and the overflow launder is filled with water to form the seal. The tank cover is put in place, and the tank is ready for leaching. With the waste valve open, the first leaching solution is led upon the sand as rapidly as possible and displacement of the water by the pregnant solution begins. After a period of about 2½ hr. the first traces of ammonia appear at the waste valve, which is then immediately closed and circulation through the effluent leaching-solution piping begun at the normal percolation rate. The first portion of the solution coming through is naturally low in copper and ammonia, owing to diffusion and imperfect displacement, and is run into the second leach. This solution builds up very rapidly, however, in copper and ammonia, and the subsequent course of the cycle, so far as effluent solutions is concerned, is determined by conditions existing, it being essential that the first and the second leaching solutions be maintained at their proper assay, and the amount of rich solution drawn off for distillation is governed accordingly. Naturally, over a series of tanks the amount of copper in this rich solution is equal to that extracted from the sands, but it may vary considerably from one tank to another. The aim is to have this rich solution for distillation as low in volume and as high in copper as possible, for the distillation is an important item in the total expense and the volume distilled is maintained at a minimum. As soon as the desired volume of first-leaching solution has been run on the sands, the second leaching solution is run on in the same manner, and after this is drained below the surface of the sands, it is followed by the first wash and this in turn by the second wash, which is water. The volume of water added to the cycle at this point is equal to the amount removed by distillation. This is the invariable practice so far as the ongoing solutions are concerned, although the quantity of these solutions is occasionally varied to suit the feed. The effluent solutions are not regulated with quite the same nicety, as they are affected, not only by conditions within the sand tank itself, but more particularly by the volume and assay of the solutions in storage. In general, one may say that the solution first coming off goes to the second-leach tanks until built up in copper and ammonia, after which the rich solution for distillation is drawn off. This is followed in turn by the full volume of the first leaching solution, this by the remainder of the second leaching solution and finally by the wash. This completes the leaching cycle proper, which in the ordinary operation requires about 70 hr. The tank is then flushed out through the seven gates provided for that purpose, by means of two high-pressure streams and some low-pressure water, this being completed ordinarily in 3 hr. With the 12 hr. allowed for filling, the entire operation is accomplished within 90 hr.

Before describing the distillation process, it may be of interest to explain how the leaching solutions are made and controlled. The only solvent required is purchased in liquid form, and thereby some of the difficulties attendant upon dissolving a solid for use as a solvent are avoided. We purchase carbonated ammonia liquor in tank cars from the Semet-Solvay Co., of Syracuse, N. Y., shipment being made from the company's Detroit plant. The amount of carbon dioxide in this liquor is varied by us so as to keep the percentage in the leaching solutions about the equivalent of that of ammonia. The railroad track comes directly into the leaching plant, and the contents of the tank car are forced by means of compressed air into the strong-liquor storage tanks and from these run by gravity into the mixing tank at the desired rate for maintaining the ammonia contents of the second leach. All other solutions are made up from the effluent solutions by proper selection and control. If there is any tendency for the volume of any given solution to increase or decrease, or its assay to vary, it can be compensated by varying the amount of solution to be distilled. There is absolutely no fouling of the solutions, and there is never any necessity for throwing away any portion of a leaching solution or of a wash. The total volume of all ongoing solutions and of the effluent rich solution is measured by means of recording V-notch meters, and the rate of flow of the effluent solutions from the individual sand tanks is indicated by means of gages connected to Pitot tubes and by measurements of the solution-storage tanks. These means, in connection with hourly assay samples, have been found ample for complete control of the leaching solutions and of the cycle.

Distillation of Pregnant Solution

The distillation of the rich solution with the recovery of the ammonium carbonate and the precipitation of the copper oxide is carried on in an apparatus analogous to that used in the byproduct coke industry for distilling ammonia, with the exception of the still previously described, which was developed for this particular liquor. The plant for this distillation was designed by us in connection with the engineers of the Semet-Solvay Co., who furnished all the apparatus except the stills mentioned and their accessories. About

90% of the copper content of the liquor is deposited in this still, which we call a roughing still, and is trapped off into a chamber that is discharged periodically directly into a filter box and from this loaded into concentrates cars. The other 10% of the copper remains in solution or suspension and passes through a second still of a standard type, which we call a finishing still, and from which the final solution, barren of ammonia, runs into a settling tank to permit the settling out of the copper oxide. There are two roughing stills connected in parallel, as to solution and steam, with one finishing still, and the rest of the distillation unit is made up of a reflux column, condenser, etc. The oxide of copper as precipitated by this operation will assay about 80% copper and is practically pure. It goes direct to the smelting works, where it is mixed with the native copper concentrates, and as such, since it is free from gangue, it is highly prized by the smeltery men, since the oxygen it contains aids in slagging off the impurities of the rest of the charge.

As at present operated, the daily capacity of the leaching plant is 2000 tons. The plant is run by three shifts of eight men each, and in addition to these there are six men on the day shift for repair work, the bulk of which is in connection with the stills. These with the head chemist make up the working force. Allowing an average rate to these men of $3.50 per day, there is indicated a labor cost of 5c. per ton of material treated. The repairs will be very slight, judging from the ten months of operation of the plant. The wear and tear on Dorr classifiers is not appreciable as yet, and the same is true of the sand distributor. Centrifugal sand-pump liners give some trouble, but nothing that cannot be easily handled on the Sunday morning shutdown. There has been no evidence of corrosion in the cast-iron solution pipes or in the leaching tanks. The strong liquor as received and the distillate made is somewhat corrosive, but hardly sufficient to warrant a protective lining. Fortunately, the extent of this strong-liquor line is limited and its maintenance will not become laborious. The amount of electric power consumed in the plant is equal to 225 kw., most of it being used in the operation of sands pumps which, on account of the local conditions, are numerous, since it is necessary to pump the mill tailings into the leaching pant, to pump the sands from the Dorr classifiers to the leaching tanks and also to pump the tailings from the plant back to the lake. The steam for distillation amounts to about 35% by weight of the liquor distilled and, as now operating, costs about 4c. per ton of sands treated. The greatest single item of expense is the ammonia, the loss of which is just under one pound per ton of sands treated. Under ordinary economical conditions this ammonia should not cost over 15c. per lb., but at present, owing to the excessive demand, the cost is almost double that figure. The complete record of cost for March is given in the accompanying table.

COST OF AMMONIA LEACHING

	Per Ton
General expense, including foremen and chemists	$0.031
Ammonia	.255
Sand conveying and classification	.020
Labor, power and supplies for leaching	.027
Steam for distillation	.038
Labor and supplies for distillation	.035
Total cost	$0.406

During this month there was a recovery of 8.18 lb. copper per ton of material treated, giving a cost per pound, up to smelting, of just 5c. For the first four months of the year the cost per pound of copper has been less than 4.75c. up to smelting, or about 6c. per pound sold. The present production is at a rate in excess of six million pounds per year.

The extraction varies with the fineness of the product, which so far as the leaching plant is concerned, should all be through 48-mesh, but which actually is very much coarser. As operating at present, there is some 28- and 48-mesh material on which the extraction is less than 60%, whereas on the material passing through the 150- and 200-mesh the extraction is as high as 85%. The average extraction is now about 75%. The data in the accompanying table are for April.

SANDS LEACHING PLANT, APRIL, 1917

Size of Sand Particles	Feed % Sand	Feed % Cu	Tailing % Sand	Tailing % Cu	% Extraction
On 28-mesh	3.6	0.707	2.1	0.416	29.7
28- to 48-mesh	18.3	0.619	16.9	0.214	65.4
48- to 100-mesh	44.0	0.607	46.0	0.136	77.6
100- to 200-mesh	24.2	0.575	25.1	0.094	83.7
Through 200-mesh	9.9	0.994	10.8	0.114	88.5
Average for month—total	....	0.644	....	0.141	78.1

The process was originated and developed entirely by Calumet & Hecla engineers. The mechanical details were designed by H. E. Williams and Robert MacIntosh, with helpful suggestions from Allan J. Clark, of the Homestake Mining Co. The general design of the plant and the chemical development of the process was taken care of by the writer and H. C. Kenny, the latter now in charge under Henry Fisher, mill superintendent.

Dividing a Mortar-Box

BY CHARLES LABBE
Mechanical engineer, Johnie, Nev.

In the case where a five-stamp battery mortar-box is to be divided to provide two smaller boxes or where the division is necessary for other purposes, the following method may be adopted:

With the mortar-box in its normal position a line is traced around the outside and inside, at the required distance from one end, with cold chisels, then deepened to a groove about ¼ in. deep. The position of the mortar-box is then reversed and the base of the sole-plate divided in a similar way with a cold-chisel cut and, later, with a cape-chisel groove ⅜ in. deep by ⅝ in. wide, beveled on both sides with a cold chisel. A crack is then started from the top of the mortar-box where the thickness of metal is less by means of blows from a hammer on a chisel held in the groove. Two and a half sticks of 40% powder are then firmly pressed into the groove across the sole-plate and the cap placed in the center on the top of the powder, the whole being covered with soft clay and sand to act as tamping media for the exclusion of air. Half a dozen old dies are then piled on the tamping and the fuse is lighted. The explosion will result in the division of the mortar-box along the lines traced by the cold chisels, but possible damage and injury from falling dies must not be overlooked.

In the case in point it was found necessary to conconstruct a two-stamp battery from a five-stamp mortar-box and equipment. The method outlined proved successful for the division of the mortar-box, the only difficulty present, and the rough edges of the exposed side were afterward chipped and filed to allow the placing of a heavy sheet of iron which was attached by means of cap-screws in the ordinary way.

Inhibitory Films in Flotation

BY WILL H. COGHILL

Consulting metallurgist in the coöperative work of the Oregon Bureau of Mines and Geology, and the U. S. Bureau of Mines, at Corvallis, Ore.

The selective action of oils toward various substances, minerals and rocks, being most important from the mining engineer's point of view, is ascribed to the presence or absence of films of other substances. These substances may inhibit oil filming. Proper knowledge and control of these films is believed to be essential to the highest development of flotation.

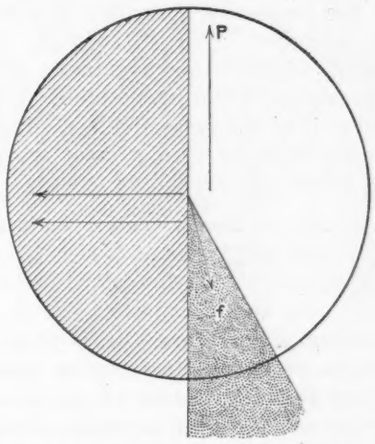
WE ARE told by W. D. Bancroft[1] that the problem of ore flotation is a very simple one or a very complex one, depending on our point of view. I believe that I am qualified to speak for the mining engineer and saying that from our point of view the problem is a very complex one. We feel that we are justified in this view because we find that the problem is complex. If a few men of Dr. Bancroft's type could find time to give flotation a little more than a passing glance they would, no doubt, in time give us a different point of view.

T. A. Rickard has said:[2] "Acified water has a greater wetting power than neutral water. For this fact also no satisfactory explanation is forthcoming." R. C. Canby[3] feels that "the question of selective affinity of oil for sulphides is confusing"; and we find that these problems which confront us today were the problems of ten years ago, as attested by Swinburne and Rudorf[4] when they say: "The strange thing is that bodies like stibnite, which have small adhesion for water and thus resemble grease, have aparently greater adhesion for grease."

I offer no panacea for this confusion of ideas. Since knowledge by our experience alone is not an ideal source because "experience teaches a dear lesson," let us see what we can learn from the experience of others.

A Fundamental Physical Principle

I believe it possible to learn from them and make the subject seem less befogged than do Rickard, Canby, Swinburne and Rudorf. One simple physical principle is fundamental to the conception that I am going to try to convey. I quote from "Mechanics, Molecular Physics and Heat," by Milliken. In discussing the spreading of a liquid on a solid, Milliken says: "The law of transmission of pressure by liquids easily accounts for this, at first view, somewhat surprising result. For, in accordance with this law, the molecular pressure P existing because of adhesion at a point in the liquid close to the limit of contact, as shown in Fig. 1, is transmitted undiminished in a direction parallel to the surface of the solid, and therefore constitutes a force pushing out the molecules. The only opposing force acting to prevent the limiting molecules from moving up along the surface is the vertical component of the attraction f exerted upon these molecules by such portion of the liquid as lies within the sphere of influence about the center. Hence, unless the ratio of cohesion to the adhesion exceeds a certain limit, a thin film of the liquid must spread out indefinitely over the surface of the solid. This conclusion is not surprising, since it means simply that a body that attracts a liquid strongly enough will draw every particle of it as near as possible to itself." Milliken goes on to say that perfectly clean surfaces with great adhesive power are very difficult to obtain, and that on account of the prevalence of this very phenomenon. I see here two very important lessons: The liquid with the highest value for $\frac{P}{f}$ is the most likely to spread and will spread if the adhesive force of the solid is sufficiently great; second, on account of the great surface tension of some of the solids, it is nearly impossible to secure an uncontaminated surface. With those two principles as a basis, we can correlate the observations of the amalgamator, galvanizer, ceramist and horticulturist, also the specialists in lubricants, dyes and soaps. We know full well how very thoroughly a copper plate must be cleaned before mercury will spread on it. When a fresh surface is once secured, the mercury spreads freely and adheres with such tenacity that it defies even fire. The amalgamator says it "bites." The force P is so great that f is really negligible when the molecules of the mercury and copper come within the effective range of molecular attraction.



OPERATION OF SURFACE FORCES

Liquid zinc will not "bite" an iron wire unless the wire's surface is freed from all impurities. The impurities lack the adhesive power that the iron possesses and therefore must be removed. When the wire is clean, the zinc spreads freely and a galvanized surface is the result. Mercury spreads freely on gold when there is no contaminating film.

There may be those who, looking upon amalgamating and galvanizing as chemical and not physical phenomena, object to this correlation. But the barrier is more apparent than real, for Irving Langmuir[5] says, in speaking of solids and liquids: "In gases there is usually no uncertainty as to the size of the molecules, but in liquids and solids no really satisfactory methods have been found for determining molecular weights. So long as we cannot definitely determine the molecular weights, it thus remains impossible to distinguish

[1] "Met. and Chem. Eng.," June 1, 1916.
[2] "The Flotation Process," by Rickard, p. 131.
[3] "Eng. and Min. Journ.," July 1, 1916, p. 30.
[4] "Eng. and Min. Journ.," Feb. 10, 1906, p. 276.
[5] "Constitution and Fundamental Properties of Solids and Liquids," "Jour. Am. Soc.," November, 1916, p. 2225.

sharply between chemical and physical phenomena. Nevertheless, much discussion has arisen of late years over such questions whether adsorption and surface tension are chemical or physical phenomena. The overwhelming consensus of opinion seems to be that these are both physical phenomena. In the following pages the writer hopes to show that there is no present justification for this distinction between chemical and physical forces. Cohesion, adsorption and surface tension are all manifestations of forces similar in their nature to those acting between the atoms of solid bodies. It is therefore advantageous to look upon these forces as direct results of chemical affinity." Mr. Langmuir, in placing surface tension among chemical phenomena, does not ask us to unlearn things once learned, but on the other hand, comes to our rescue with a more complete equipment for our task.

Mercury spreads on copper and gold, and zinc, tin and lead spread on iron because $\frac{P}{f}$ "exceeds a certain limit." If we take advantage of the interchangeability suggested by Langmuir, we can interchange terms and substitute surface tension for P and f and establish the hypothesis that the surface tension of these solids is greater than that of the respective spreading liquids. The appended table, compiled from "Handbook of Chemistry and Physics," justifies this hypothesis for the solids, at the temperatures shown in the table, have a greater surface tension than the respective spreading liquids and it would doubtless be even greater when

SURFACE TENSION OF SOLIDS AND SPREADING LIQUIDS

	Solid			Spreading Liquid		
No.	Metal	Temp. C.	Sur. Ten.	Metal	Temp. C.	Sur. Ten.
1.	Copper	1,100	580	Mercury	15	436
2.	Gold	1,070	612	Mercury	15	436
3.	Iron	1,200	1,000	Zinc	360	877
4.	Iron	1,200	1,000	Tin	250	352
5.	Iron	1,200	1,000	Lead	330	448

they were at the working temperature. It is likely, therefore, that a solid has greater surface tension than the spreading liquid and that the tension of the solid could be predicted by testing its power to make liquids of a large range of tension spread upon it.

It is commonly stated in physical literature that solid substances do not manifest their molecular forces as freely as do liquids for the reason that their surfaces are fixed. This must not be taken to mean that we cannot approximate their surface tension, for we have just done that very thing in the case of copper, iron and gold. The interchangeability of cohesion, adhesion and surface tension permits this approximation, but it is not infallible. For example, the surface tension of platinum at 2000° C. is 1658. It is difficult to account for the failure of mercury to spread on it (amalgamate). If we cannot attribute its rebellious nature to inhibitory films that the mercury cannot dissolve (and films are the result of high surface tension), we shall have to await a clearer conception of surface tension from a chemical point of view.

The force P at the surface of coal, is not sufficiently great to make pure water spread freely upon it. This spreading is desirable in the sprinkling of coal mines, and since it is not feasible to increase P by polishing as is the custom with a copper plate, or by using acid as in galvanizing, f must be altered. Reducing f is just as effective as increasing P. This reduction is accomplished by adding soap to the water. If Mr. Rickard had known this and had he known also that certain acids[6] reduce the surface tension of "neutral" water, he could have answered his own question.

Returning to the subject of the wetting of coal, I quote[7] as follows:

"These dust-laying processes have been duly considered by Dr. Thornton, who has made experiments favoring the view that an efficacious spraying mixture can be made with soap and water. He demonstrated that the whole question of the wetting of dust was one of surface tension of the liquid used, and that the water alone did not possess the property of readily wetting the coal dust, unless indeed it was used in large quantities. On the other hand, the soap and water mixture completely wetted the dust, turning it into a liquefied form of mud, the chief component of which was coal dust." The coal miner has thus applied nature's laws to commercial work. Thanks to him for putting his results on record.

Comparison with the Principle of Detergents

The incorporation of this principle of Milliken's into the science of detergents, according to W. E. Hillyer,[8] antedates its application in coal mining. What he suggested in 1903 as a "possible factor" is now a generally accepted fact in the literature on detergents. He says: "We have seen before that another possible factor in cleaning, namely, the power which soap solutions have of wetting oily substances, is due to the soap itself. But this wetting power may be experienced only by the strong adhesion of the soap to the oil (P) and the low cohesion of the soap solution itself (f). The latter will more easily spread out over the surface if its cohesion is small, and a stronger force will be acting to spread it out if it is strongly attracted to the oily surface."

We have concerned ourselves much about oil spreading on water, but we see that the soap specialist must make a water solution that will spread on oil, otherwise his soap is a failure. Indeed, his soap acts as a solvent upon certain oils, but in addition to this property the spreading and lubricating power of the soap solution is essential. Soluble oil is only one form of dirt. There are many others, and they must be lubricated by a spreading or wetting liquid before they will slip off the fiber. If they slip off and become permanently suspended in the soap solution, the cleansing of the fiber is complete.

Knowledge of the principles governing the spreading of liquids is fundamental in flotation. I am trying to indicate where this literature can be found, the nature and application of it. In the tardy recognition of the importance of these principles we—as mining engineers—do not stand alone. I refer to our own United States Department of Agriculture. Cooper and Nuttall[9] write very interestingly about this while discussing the subject of dipping and spraying the solutions. We read as follows: "No proprietary dip is now recognized unless the manufacturer can furnish a 'Field Tester,' by means of which the stock breeder can himself determine in a simple and fairly trustworthy manner the percentage of active constituent in his bath. The underlying idea upon which all these regulations are based

[6]Organic acids are more likely to depress the tension of water than are the inorganic acids.

[7]"Eng. and Min. Journ.," Mar. 11, 1911, p. 531

[8]"On the Cleaning Power of Soap," "Jour. Am. Chem. Soc.," Vol. 25.

[9]"Journal of Agricultural Science," Vol. 7, 1915; "The Determination of the Wetting Power of Dipping and Spraying Fluids."

is that the principal factor, which determines the efficacy of a dipping fluid, is the quantity of toxic substance present. It has been shown, however, in experience derived from field experiments and routine dipping, that this assumption is unwarranted. There is another factor of almost equal importance; namely, the capacity of the dipping fluid to wet the greasy hide or fleece. The fact that the Queensland official dip contains soap as a basis may be quoted as an indication that the importance of the wetting power of dipping fluids is recognized in actual practice." Continuing, they say: "What has been said of dipping fluids refers with equal force to horticultural spraying fluids—a high percentage of toxic substance is no criterion of the efficiency. The supreme importance of the spraying fluid having a high wetting power is gradually becoming more and more recognized, though not generally by government authorities. In the United States compulsory spraying is rapidly becoming the rule, and the standardization of spraying fluids is its natural consequence. This standardization merely considers the percentage of toxic agent and entirely disregards the equally important point of the wetting power."

We see from the foregoing that spreading is facilitated by removal of an inhibitory film, as for example, on copper plates and iron wire, thus increasing P, or by adding a contaminant to the liquid, as for example, when spraying coal or trees and, when washing or dipping, with a consequent reduction of f.

The Problem of Immiscible Liquids

The problem becomes more difficult when we have two immiscible liquids and wish to determine which will spread on a given solid. Let us take some examples for illustration. R. C. Canby says that "sulphide surfaces are so delicate that even the merest drying of wet surfaces may have an effect that is sufficient to prevent successful flotation." This trouble is doubtless due to inhibitory films. We should have foreseen the possibility of this obstacle, since it is known that at one extreme there is a group of solids on which water inhibits the spreading of oil, an intermediate group which is uncertain, and at the other extreme there are solids on which oil inhibits the spreading of water. Some examples will be of value. They appear here in the order just given.

1. The first, though stated in a manner possibly out of the ordinary, is one of the most familiar. It is: Water inhibits the spreading of oil on quartz. It has not been our custom to take into account the inhibiting power of the water, but I think that this interpretation will be correct when considered with what follows.

2. We have a striking parallel in the testing of lubricating oils. It is recorded by Archbutt and Deeley.[10] Concerning the testing of lubricating oils in a film on a glass plate, they say: "It is not easy to obtain a continuous film, nor films of uniform thickness, and unless they are uniform the results are not comparable. The least trace of moisture on the surface of the glass, even the film of moist air condensed on all apparently dry cold surfaces, causes some oils to draw up into irregular patches and drops. This may be avoided by first heating the glass strongly and painting it with the oil while still hot."

[10] "Lubrication and Lubricants," p. 304.

3. Similar conduct is experienced in making asphalt pavements[11] where it is found that the paint coat, consisting of asphalt cement dissolved in benzine, cannot be successfully applied to concrete that is in the slightest degree damp, as the adhesion is then imperfect.

4. The ceramist has had experience with oil and water. We read[12]: "Ether, gasoline, kerosene, engine oil and similar liquids form an inhibitory coating over the clay grains and prevent the display of plastic properties. These liquids are insoluble in water. Though they are to some extent able to prevent the formation of the plastic bond, they are unable to break this bond once it has been formed." If the clay grains could be dried thoroughly and then oiled, the inhibition of water would be complete.

5. The magnetic paint for the Murex process could not be made in the presence of water. It was therefore made up in a separate apparatus and added to the pulp. Mr. Ralston[13] notes that some difficulty was met in the tendency of the ground magnetite or other material to leave the oil and go into the water.

Applications of Principles in Road Building

6. The road builder has found it difficult to make the oil film inhibit water. He says[14]: "The different kinds of rock surfaces behave quite differently toward asphalt cement. The porous limestone surface absorbs it and, of course, adheres very firmly. To the quartz surfaces the bitumen adheres in most cases well, but in others only slightly, being readily washed off with water. A sand from the London gravels has a surface such that asphalt cement would not adhere to it in the presence of the dampness of a London fog, so that it would be found in the gutter after a rain, washed quite clear and free from bitumen."

7. Archbutt and Deeley, in discussing lubricants, say that water, although it has a greater surface tension, cannot, as a rule, displace oils, fats, grease, etc., from surfaces of solids (they have metallic surfaces in mind), for such substances are insoluble in water and insinuate themselves among the surface particles of the solid, from which they are not easily separated. George B. Upton[15] deals with lubrication and selective spreading more intelligently. He says: "This (surface tension) and the adhesion of oil to metal surfaces are the forces which cause oil to spread over the metal and to crawl into the thin spaces between bearing and shaft, or piston and cylinder, while the metal parts are at rest. Animal and vegetable oils adhere better to metal surfaces than do mineral oils. This property is especially important in steam-engine valve and cylinder lubrication, where the oil must adhere to the metal so strongly that water, and the tendency of oil to float on water, cannot remove the oil film. Mineral oils, pure, may be displaced from a steam-engine cylinder wall or valve seat by hot water. The adding of small amounts of animal or vegetable oil to the mineral steam cylinder oil helps the oil film to adhere. The good effect is important enough to counterbalance the bad tendency of the animal or vegetable oil to form acids. Where water

[11] "The Modern Asphalt Pavement," by Richardson.

[12] "Physics of the Clay Molecule," by R. F. McMichael, American Ceramics Society, Vol. 17, 1915, p. 622.

[13] "Eng. and Min. Journ.", Apr. 29, 1916, p. 765.

[14] "The Modern Asphalt Pavement," by Richardson.

[15] "Properties of Oil and Their Relation to Lubrication," by Upton, "Sibley Journal of Engineering," June, 1916."

is absent, the mineral oils stick well enough on metal surfaces. Surface tension of lubricating oils is not usually noticed in testing."

8. Grease or oil displaces water on diamonds, graphite and sulphides. The first five examples need no further comment; the last three do.

In (6) the impression is given that, since the "porous" limestone surface absorbs the oil, the quartz could not be expected to adhere to oil because it is not porous. This is not correct; porosity is no measure of adhesion. An ink blotter is porous, but it will not soak up mercury because f is too great as compared with P. All substances are porous, but it is only when f is sufficiently small that a liquid will soak in, thus making the porosity apparent.

In (7) where the authors say, "insinuate themselves among the surface particles of the solid," they show an adherence to the fallacy that I tried to expose in (6). If a porous surface were the only prerequisite in order that a liquid might "insinute itself among the surface particles and not be easily separated," artificial magnetite would have been an ideal material from which to make magnetic paint for the Murex process, but we know that it was not. There must be more than a porous surface. The liquid must have a capillarity such that it will be drawn into the pores.

The apology in (7) for water not being able to displace grease, though it has a greater surface tension than grease, is prompted by an early impression emanating from Lord Rayleigh. He showed that "when several liquids are brought into contact with a solid whose surface tension is greater than that of either of them, the conditions of equilibrium or of minimum potential energy are satisfied when the liquid of greatest surface tension is in contact with the solid, and the other liquids assume the order of their relative surface tension." This orderly arrangement maintains when, as is well known, water replaces oil in the wick of a lamp and makes the flame sputter, but when water will not replace grease on metal (7), the lubrication expert attributes it to insinuation. Any lack of coördination with Rayleigh's principle needs no comment further than to say that if one liquid is not replaced by another on a solid, the fact that the one has spread and formed an inhibitory film that prevents the other from coming within the effective range of attraction is good and sufficient reason.

The last (8), is paramount; and with it we have Canby's "paradox," "The strange thing is that bodies like stibnite, which have small adhesion for water and thus resemble grease, have apparently greater adhesion for grease." This bugbear has confronted the mining engineer for ten years. I wish it could be removed. I believe that a working knowledge of the principles that I have outlined will enable us to remove it. The problem is: Given, that water does not spread on sulphides; why does oil spread on them at the air and water interfaces?

Proper Distribution of Molecular Forces

When oil spreads on sulphides at the air interface, it is because molecular forces are distributed in such a way that $\frac{P}{f}$ is sufficiently great to make it spread.. This is a natural consequence of reducing surface tension of the spreading liquid and finds a striking analogy in the case of the soap solution and coal. Analogies are, in fact, abundant and there is no reason why one should be looked upon as a paradox while the others are passed without comment.

Again, we can apply well-known principles and show that the spreading of oil at the water-sulphide interface is far from paradoxical. It will be recalled that our working definition of surface tension incorporated the principle that the combined effect (from the viewpoint of energy expended) of a molecule moving about within a liquid was zero. Now imagine a drop of oil in water. It can move about with perfect freedom because the retarding force caused by pulling the molecules apart on the advance side equals the accelerating force of reunion at the rear. But assume that this drop of oil has moved to the water-sulphide interface. Here it receives a net accelerating force along the solid surface because the energy of the water molecules closing behind it is greater than that required to separate the water layer from the solid. Because of this unbalanced force the oil droplet will spread between the water and the sulphide just as putty spreads between the fingers when squeezed in the hand. This is, of course, in opposition to the law of minimum potential energy of surfaces, for it is obvious that the droplet experiences an enormous increase in surface, and therefore surface energy, but it must be borne in mind that liquids only tend to reduce surface to a minimum. There are many ways in which this tendency meets opposing and even controlling forces.

The oil therefore spreads between the two phases. It spreads on either water or sulphide at the air interface, therefore it seems natural rather than paradoxical for it to spread at the water-sulphide interface if the water has not already spread. Having once spread, it forms an inhibitory film that checks other liquids from coming within the range of molecular activity of the sulphide. When the sulphides have depressions filled with entrapped air, as they doubtless have, the oil does not have to break the adhering bond at these spots, but spreads freely on both the air-sulphide and air-water interfaces.

Oil cannot spread upon quartz in water because water has spread upon it and formed an inhibitory film. It might be urged that oil will spread on water-filmed quartz in the air, but such an oil film could not be expected to remain unaltered when submerged because it is well known that a drop of oil between layers of water draws up into a sphere. If we increase the surface tension of water so that f is sufficiently great to prevent water from spreading on the quartz, then oil will doubtless spread at the quartz-water interface. If we add pine oil to our water with a consequent reduction in f so that the water spreads on the sulphides, it will be useless to add tar. But it is not done that way. The tar is added first, and after it has formed an inhibitory film over the sulphides, we add pine oil.[16] The pine oil doubtless assists by producing a contaminated water that is more effective than pure water in spreading over quartz, but if it were of such a nature that it made f so small that the liquid spread on tar we would be defeated in our tarring; we would, in reality, convert the flotation machine into a washing machine.

[16] I understand fully that the tar and pine oil are sometimes added at once, and will show later that it is not impossible to do this in conformity with natural laws.

It may be that with those ores where it is difficult to get the tar to spread on the sulphides, we should use a calcium-chloride brine to increase f during the tarring period. If $\frac{P}{f}$ of the sulphide-tar interface, were not sufficiently great, this process would be defeated again.

If sulphides become refractory on exposure to the air, it is probably due to the formation of a film with sufficient adhesive power toward water to make it spread. It seems consistent, therefore, in this case to undertake the tarring in the presence of strong calcium-chloride brine and then, after the removal of the brine, proceed in the ordinary way. There is the possibility, of course, that the tar will peel off prematurely, as it did in the steam cylinder, the Murex process and on the London streets. A tar with a very low surface tension should be chosen. If this fails we have, as an alternative, the privilege of visiting the dyer and cleaner for a method of removing films.

Drying Flotation Concentrates

BY H. H. ADAMS*

The problem of drying flotation concentrates appears to be as trying now as in the early days of flotation practice. The pressure-type filter, in which the pulp is subject to varying lengths of treatment, will produce material containing less moisture than the vacuum type, but at a higher cost per ton treated. The tonnage of this type of filter will not be so great, but in cases of small plants remote from smelteries, where a high freight rate is to be contended with, the extra cost of operation will be offset by the saving in freight charges. The vacuum-type machines are ideal for plants in close proximity to smelteries, because of their capacity and ease of operation. It is noted that the latter-type machines will in some cases produce a product of very low moisture content, but conditions must always be favorable; that is, the pulp must consist of at least 50% solids, contain considerable granular material and be free from fine insoluble matter.

In the treatment of a low-grade copper ore the economic mineral being chalcopyrite, in which a vacuum-type machine 8 ft. diameter by 6 ft. face is used, it is found that the moisture content varies directly with the amount of insoluble and minus 200-mesh material contained in the pulp; that a speed of one revolution of the drum in 12 min. will give a drier cake than with a speed of one revolution in 8 min., and as moisture content is reduced below 50%, a corresponding reduction in the cake will be noted within certain limits, as well as an increase in the capacity of the machine.

As a rule, when the thickness of the cake becomes greater than $\frac{3}{4}$-in., the amount of water carried in it will be more than in a cake of less thickness. Heating of pulp to 90° F. before filtering is found to increase the capacity of the machine, but does not lower the moisture content of cake. The addition of lime to the pulp at the rate of 10 lb. per ton of concentrates adds materially to the capacity of the machine and gives a drier product. Covers of the twill type have been found to give longer service than those of more open weave, likewise a cake containing less water, although more fine insoluble material will work into the fabric and resist the action of the "blow," causing the cloth to blind. Usually, a thorough scrubbing of the cloth with a stiff-fiber brush or one made of fine wires, after which a wash with a solution of 10% hydrochloric acid, followed by a wash with clear water, will relieve trouble and add greatly to the life of a cloth.

Mechanical agitation of the pulp after its introduction into the filter tank is more satisfactory than agitation by air alone, since coarse particles in the pulp do not have a tendency to build up on the sides of the tank. Application of air in connection with a mechanical agitator is generally unnecessary, and where the capacity of a compressor is limited, the air pressure should be conserved as much as possible for the "blow." A high vacuum is absolutely essential to good work, and care should be taken to see that it is maintained at the maximum point at all times.

*Utah Leasing Co., Newhouse, Utah.

Magnesite Furnace Lining

The Western Metals Co., of Los Angeles, which is operating a smeltery near that city for antimony ores, uses magnesite from the Bissell, Calif., deposit for lining its firebrick furnaces, says Charles G. Yale of the United States Geological Survey.[1] The bottoms are lined with ordinary dead-burned magnesite, tamped in a moist condition, without binder. Corrosion takes place on the side walls only, for the plastic or fine-ground magnesite is mixed with a solution of sulphate of magnesia and this with the coarser dead-burned magnesite, and the mixture is laid on the walls by plastering to make a body. The outer brick wall of the furnace is thus lined with 5 in. of plastering at the top and 9 in. at the bottom. This inner-wall lining is monolithic.

The sulphate solution is made by dissolving a pound of sulphate of magnesia crystals in a pint of water, making about a pint and a third of solution. The concrete mixture for the walls requires about eight hours to set hard, after which it should stand a week to dry out before firing and be fired gradually. For the furnace roofs molds are used to make blocks of the mixture described, and the blocks are allowed to stand a week or two before using. One part of the ground plastic to two parts of the dead-burned grain magnesite is used.

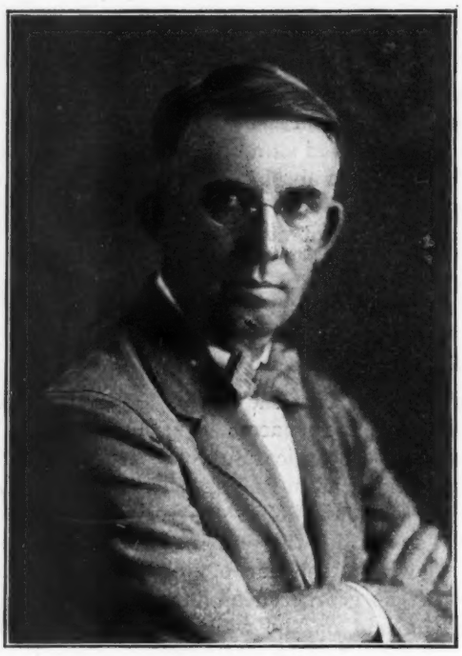
[1]"Magnesite in 1915."

Cyanides from Atmospheric Nitrogen

In a paper read before a recent meeting of the American Institute of Chemical Engineers, J. F. Bucher claims to have devised an economical process for manufacturing cyanide by causing atmospheric nitrogen to act on a mixture of sodium carbonate, graphite and powdered iron at comparatively low temperatures.

In his experiments, nitrogen was passed over briquets made of soda ash, coke and powdered iron, in equal proportions without binding medium, at a temperature not exceeding 920° C., in a "batch" furnace. At the end of half an hour the briquets contained 30% NaCN. Considerable quantities are formed even below 820° C. Air, producer gas, flue gas or combustion gases give as good results as nitrogen. Iron must be present.

Prominent Engineers in the American Practice of Ore-Dressing



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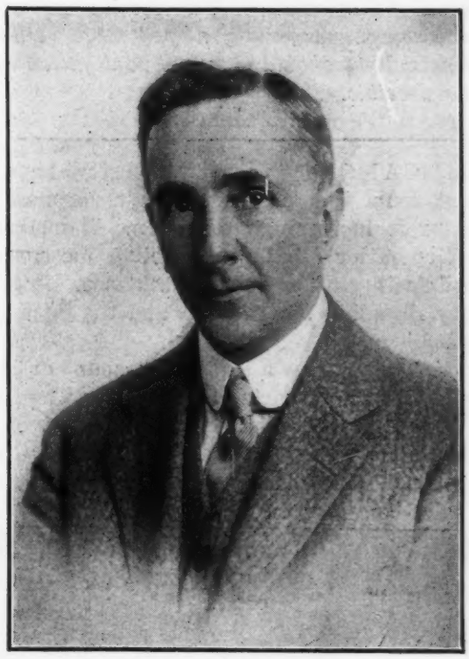
C. H. BENEDICT
Of the Calumet & Hecla Mining Co.



JAMES JOHNSTON
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Hints About Mill Lighting

By A. L. POWELL
Engineer for the Edison Lamp Works, Harrison, N. J.

The illumination of a plant affects its output. The selection of lamps and reflectors for the different parts of a mill should depend on the heights at which they must be hung and on the amount of light desired. The development of the mazda lamp has greatly helped table recovery. Artificial light should simulate daylight as nearly as possible.

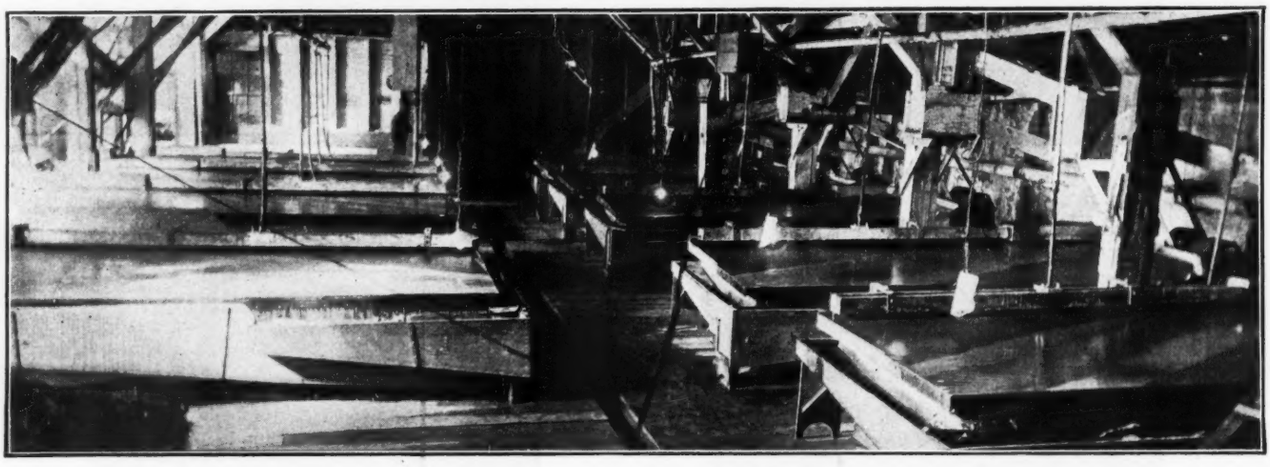
INVESTIGATIONS in every industry have shown without doubt that proper lighting is a most important factor in increasing production. It increases the speed of operation. It lessens spoilage because of the increased facility of inspecting each step. It promotes safety by revealing obstructions and the moving parts of all machinery.

Good lighting means a sufficient amount or intensity of illumination in all parts of the room. The illumination should be evenly distributed. Sources of bright light should be kept out of the field of view. Glare and flicker should be avoided, as both are annoying and trying to the eye. The color of the light used should be adapted to the class of work.

The two important elements of a lighting unit are the lamp and the reflector. The mazda lamp has become practically the standard illuminant for interior lighting. It is cheap and simple and requires no repairs or adjustments. It has long life without decreasing materially in candlepower, does not flicker, and is available in a wide range of sizes from 8 to nearly 2000 candlepower. The color of the unmodified light is practically white with a slight yellowish tint, but by the use of special bulbs, or auxiliary glassware, this can be modified to give various effects.

A reflector is necessary to redirect the light in useful directions. It gathers the light that would go upward and sideways and send it to the work. It shields the eye from the bright lamp filament and often serves to protect the lamp from injury. The nature of the work in a concentrator makes it advisable to install well-made, substantial reflectors. One made of thin metal or cheaply put together is poor economy. Its useful life is short. For practically all industrial lighting steel reflectors have become standard. These are made either with a porcelain enameled finish or with aluminum reflecting surfaces. Where the air is moist, as in most mills, a good grade of porcelain enamel is desirable to protect the metal against rust. The enameled reflector can, moreover, be easily cleaned. Dust will accumulate on reflecting equipment and, if not removed, will lower the efficiency of the installation. This latter point cannot be impressed too strongly.

The standard types of reflectors for interior lighting are the bowl, the dome and the angle. The bowl comes down well over the lamp and prevents light escaping near the horizontal. It should be used where lamps are hung far above the object to be lighted or where the light at high angles would be wasted on the side walls. The dome reflector is the one most commonly used. It is the most efficient of the three types, and at medium hanging height is the most satisfactory. It lights up vertical surfaces better than the bowl type.



INTERIOR OF ONE MILL, SHOWING METHOD OF LIGHTING UP TABLES

The angle reflector is similar in shape to the bowl, but has its holder or socket so placed that the maximum light is directed to the side rather than downward. It is well suited for use along the side of a room.

In all parts of the yard, tracks, ditches and other obstructions must be visible. The danger of accidents is minimized if the light is well distributed from a number of relatively small units. Such a system may not be more economical than employing a few large lamps, but the use of a medium-sized unit enables one to place lights near important points, such as crossovers and switches. Mazda lamps of 60 to 150 watts are well suited for low-intensity yard lighting, while 200- to 500-watt units are adapted for high-intensity illumination. If typical street-lighting equipment, such as the radial wave reflector, is used, it is possible to space the lamps widely and yet have no dark spots between units. Yard-lighting equipment can be suspended from cables strung

between buildings or placed on brackets on poles or on the sides of the building.

On the ore bins general illumination of a low intensity is adequate, light being needed only for safety. The runway should be lighted by rows of medium-size mazda lamps so spaced and hung that the illumination is fairly uniform. As with any lighting problem, the size of lamp will depend on the maximum available hanging height. If, on the bins, the lamps could be hung from 15 to 18 ft. above the walk, then 200-watt mazda lamps with dome-shaped enamel steel reflectors on 30-ft. centers will give sufficient illumination.

As to apron feeders and conveyors, no specific recommendation could be made which would hold good for a number of plants. Each proposition is peculiar to itself. Lamps with suitable steel reflectors should be located at the spots where loading and dumping takes place, or where the mechanism may have to be repaired.

In modern mills, grizzlies and crushers are usually in a part of the plant with high headroom and a combination of two types of lighting proves most satisfactory. Large mazda lamps of 500 to 1000 watts in deep-bowl steel reflectors placed close to the roof above the crane travels, spaced so that overhanging parts do not cast shadows, form one type. This should be supplemented by medium-sized mazda lamps in angle steel reflectors below the crane travel on the wall opposite the machines. These units provide illumination on vertical surfaces and tend to send the light into the mechanism. In this and other parts of the plant where vibration is severe, flexible rather than rigid suspensions for the lamps are desirable.

General illumination from medium-sized mazda lamps with deep-bowl steel reflectors placed above the crane travel suffices where ball or tube mills are used. From 0.3 to 0.6 watt per sq.ft. of floor area are rough figures on which to base calculations for such work as this, where the operators must see that the machinery is feeding properly and make occasional adjustments.

The low ceilings in many mills where roughing tables and classifiers are used, necessitates rather small lamps spaced quite closely. The enameled dome steel reflector gives a suitable distribution of light for such work. Particular attention must be paid to the placement of lamps to prevent shadows from surrounding equipment.

The improved finishing tables have enabled the mills to obtain much better recoveries than was dreamed of in the early days. This fact has made mining of lean ores profitable, and in many cases the dumps and tailings are being worked over with good results. Years ago zinc and iron were not readily separated. Iron-laden zinc concentrates could not be smelted when much of the former was present. In fact, iron mixed with zinc, lead, silver or copper was a great nuisance, and a mill could not have been made to successfully work such ore at a satisfactory profit.

Improved tables have enabled the mills practically to separate the iron and zinc streaks as they are washed over the table. It is difficult to distinguish the colors of the two streaks. Yet it is necessary for the operators to detect the difference and separate most of the iron from the zinc. In other plants it is necessary to separate scheelite from quartz, a difficult problem under ordinary artificial illumination. The development of the mazda lamp has greatly helped in this respect.

With each increase in efficiency of the incandescent lamp, the filament has operated at a higher temperature and the emitted light has been nearer white. The light from the Gem lamp was whiter than that from the carbon lamp. The vacuum mazda lamp was superior to the Gem and the gas-filled mazda lamp a still greater step forward.

A new mazda lamp has been developed with its object that of producing light whose spectral or color composition closely simulates that of daylight. If one analyzes the light from the ordinary mazda lamp with a spectrophotometer, it is found to possess a preponderance of light in the red end of the spectrum with a relatively smaller proportion of light at the blue end. As previously stated, the higher the operating temperature of the filament, the nearer the emitted light is to white, or the greater the proportion of blue light to red light. Therefore, the first step in the design of a lamp to give approximate daylight is to equip it with a filament operating at as high a temperature as economically feasible. Further by using bulbs of a specially selected blue glass it is possible to filter out some of the preponderant red and yellow rays, producing a resultant light similar to sunlight.

New South Wales Mineral Production

The report of the New South Wales Department of Mines for 1916 has just been issued, and gives the figures of production shown in the accompanying table.

NEW SOUTH WALES MINERAL PRODUCTION, 1915 AND 1916

Substance	Unit	1915	1916
Alunite	tons	1,420	325
Antimony (metal and ore)	tons	637	616
Bismuth (metal and ore)	tons	18	30
Coal	tons	9,449,008	1,127,161
Coke	tons	417,753	437,587
Copper (ingots, matte and ore)*	tons	6,973	6,171
Diamonds	carats	839	1,901
Gold	oz.	132,498	108,145
Iron	tons	76,318	52,556
Iron, "oxide"	tons	2,294	2,461
Ironstone flux	tons	.....	1,472
Lead (pig, etc.)	tons	30,305	25,466
Lime	tons	33,010	26,063
Limestone flux	tons	71,720	64,928
Molybdenite	tons	32	54
Platinum	oz.	56	82
Silver (ingots and matte)	oz.	3,237,432	2,801,507
Silver-lead, ore, concentrates, etc	tons	282,776	249,849
Shale (oil)	tons	15,474	17,425
Scheelite	tons	33	81
Tin (ingots and ore)†	tons	2,188	2,129
Wolfram	tons	50	183
Zinc (spelter and concentrates)	tons	190,916	209,741

* Does not include copper produced in New South Wales from ore imported from other Australian states. † Does not include tin refined in New South Wales from imported ores.

In addition to the foregoing, marble valued at £1625; opal, £21,273; portland cement, £420,928; building stone, £65, and sundry minerals and ores valued at £41,184 were produced in 1916.

The total value of the mineral yield in 1916 was £10,975,742, an increase of £911,173 over that of the previous year.

The number of persons employed in mining in 1916 is estimated at 31,304, a decrease of 107 from the figures of the previous year.

The Broken Hill Proprietary Co., of Australia, in its report for the year ended Nov. 30, 1916, notes that the zinc-flotation plant was completed and treated 13,232 tons of tailings, producing 2805 tons of zinc concentrates assaying 47.41% Zn, 13.02 oz. Ag and 5.72% Pb. The plant is designed to produce separately zinc and lead concentrates from the slimes and does so satisfactorily, the lead concentrates assaying 56% lead and containing most of the silver, about 80 oz. per ton.

Oil Concentration of Lead Carbonate at Darwin, California

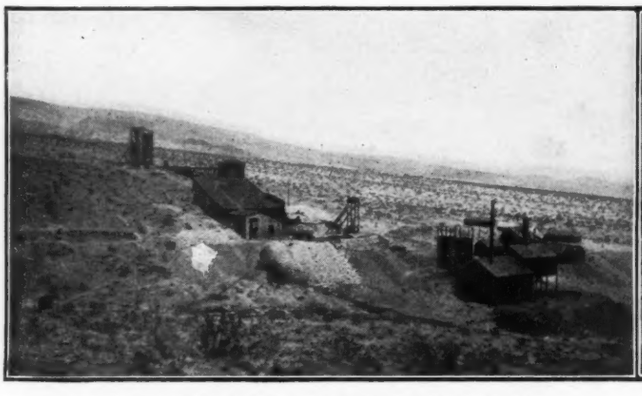
By H. S. REXWORTHY

Mill Manager, Darwin Lead and Silver Mines and Development Co., Darwin, Inyo County, Calif.

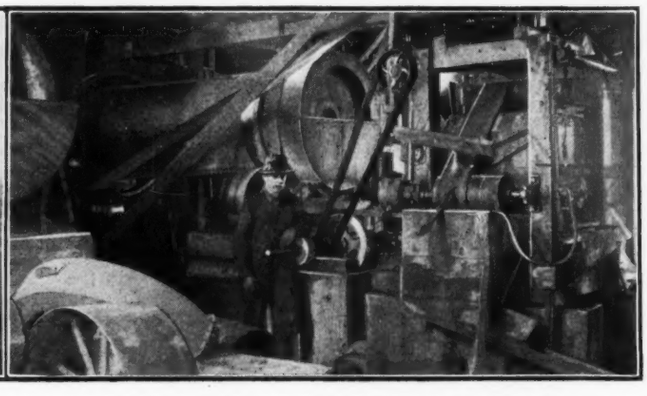
The Murex process is in successful operation at Darwin, Calif., on lead-carbonate ores. The process depends upon the selective property of oils for minerals, which is depended upon to coat the mineral particles with a magnetic paint. The painted mineral is then separated from gangue by the use of a magnet.

THE Darwin Lead and Silver Mines and Development Corporation have in operation an experimental mill for the treatment of lead carbonates and sulphide ores from its several properties situated in the vicinity of Darwin, Inyo County, California.

The company's holdings consist of seven groups, known as the Lucky Jim, Lane, Promontory, Columbia, Independence, Defiance and Thompson. The ores of these properties are widely different in character, both as regards the occurrence of the minerals and the gangues. Some of these consist of lead carbonate, carrying silver, disseminated through a hard jasper gangue, while others are a mixture of lead carbonate, galena and silver chloride in a gangue of hematite, quartz and calcite. They are mined from the upper levels down to a depth of about 600 ft., while the ores below the 600-ft. level consist of galena and some native silver in a calcite gangue.



THE MUREX MILL AT DARWIN, CALIF.



MUREX UNIT IN OPERATION AT DARWIN

The mill was built on the Lane group, owing to its central position as to the other properties and to its having within easy access a good water supply. The ores from the various properties are hauled by motor trucks and delivered from a central station by means of an aërial tramway the capacity of which is 10 tons per hour.

A 25-ton Murex oil-concentration plant has been in operation for about six months, during which time ores from the various properties have been sent down for treatment. As already stated, these ores vary considerably, each one necessitating a separate study with a view to defining the best method of treatment and, contrary to general experience with this process, it has been found that the same reagents were in most cases applicable, and good results were obtained on the different ores, including dumps, carrying considerable amounts of fines of many years' standing.

The plant is now making recoveries of from 80% to 85% of the mineral content, treating lead carbonate carrying silver and a mixture of carbonate, galena and silver chloride in gangues of hematite, quartz and calcite. The success of the process has justified adding another unit, which has now been completed, making a plant capacity of 50 tons per day.

The mill is of the gravity type, as shown in the accompanying diagram. The mill flow is as follows: Ore is drawn from the lower tramway terminal discharge shoot, weighed and delivered upon a grizzly provided with 1-in. spaces. The oversize is then fed to an 8 x 12-in. Blake-Hendy crusher, breaking down to 1-in. ring and discharging into a bin of 100 tons' capacity. The ore is fed from this bin by means of a Challenge feeder into a 20-mesh, rotary, conical screen which passes the oversize, with an addition of water in the proportion of two to one of ore, into a 4 x 3-ft. Hendy ball mill, the discharge end of which is fitted with a screen delivering a 20-mesh product mixed with the undersize from the Challange-feeder screen. The oversize in the latter case is returned to the ball mill for regrinding. By adopting this system a considerable amount of fines is eliminated from the ball mill. The pulp is then fed with a regulated mixture of oil and ground magnetite to two horizontal Murex tube agitators, each a plain steel cylinder 3 ft. diameter by 10 ft. long, revolving slowly, containing several hundred pounds of ¼-in. iron or steel punchings. These become oiled with the mixture and collect the mineral particles both fine and coarse in the form of a paste which adheres to the punchings. This paste is continously broken away by attrition and flows, with the pulp, through a slotted screen at the opposite end of the agitator, upon a brass shaking conveyor tray, which feeds it under a powerful electromagnet. The coated

mineral particles are attracted by the magnet from the thin flowing stream of pulp to the undersize of an endless belt traveling at right angles to the shaking tray, thereby suspending them until out of the magnetic field, when they are washed off by water into a concentrates bin of large capacity, provided with a divisional bulkhead and end doors in which the concentrates are delivered and discharged alternately. They are finally hauled by tram wagons and sacked ready for shipment.

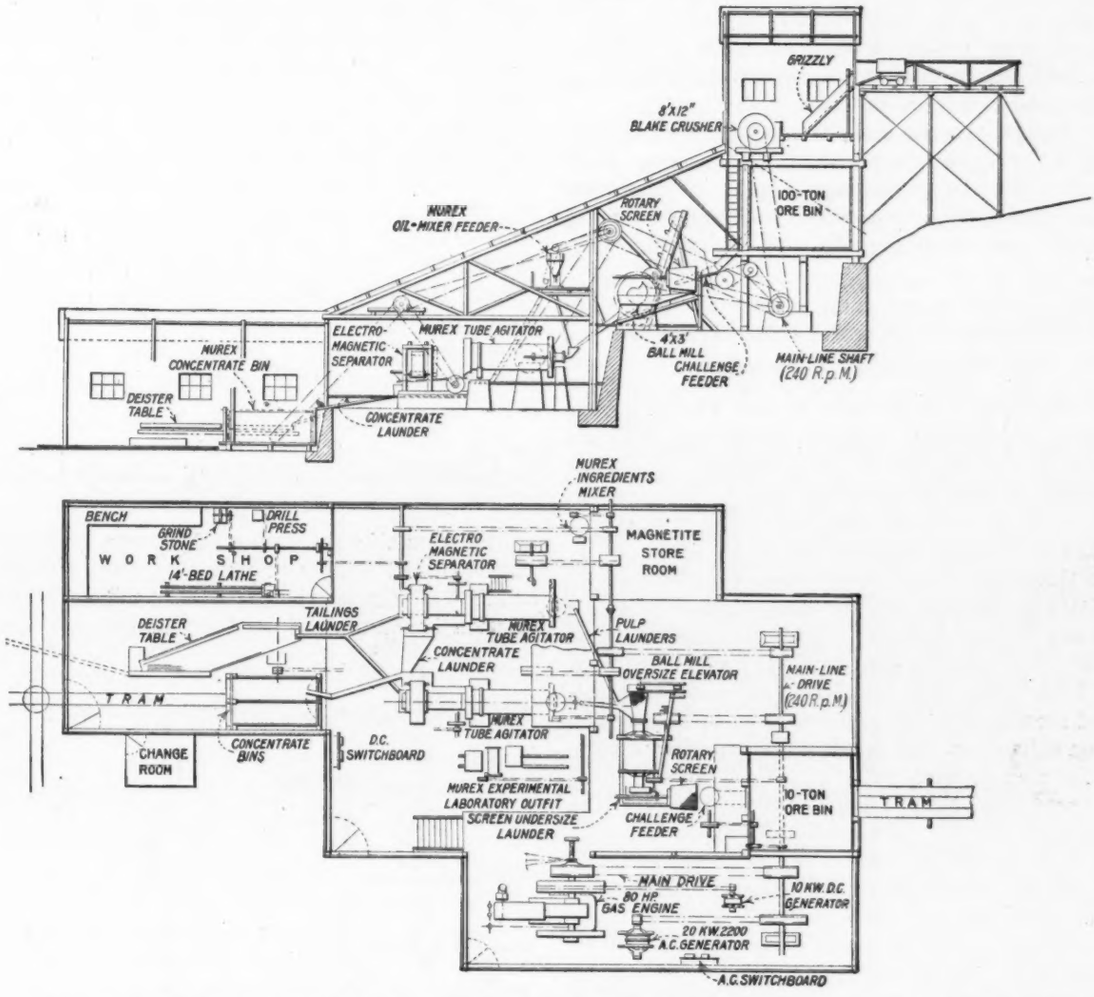
The overflow water from the concentrates bin and tailings together is passed over a Deister concentrating table. This is employed as a means of indicating to the millman any inefficiency brought about by bad coating or change in crude-ore feed, etc., at a glance. This can be seen by a small mineral streak appearing on the table. In such cases the operator makes the necessary adjustments in the oil-mixture feed to meet the new conditions.

The tailings finally pass to a large wooden spitzkasten where the coarse sands are settled out and the overflow discharges into four 20-ft. square settling ponds, from which the clear water is returned to the mill, to be used over again. This water contains a certain amount of emulsified oil, and is found to be beneficial to the Murex process, since the oil can be made use of in further ore treatment.

An 80-hp. gas engine provides power for the mill and a 10-kw. d.c. generator current for the magnets and lighting of the camp. Also a 20-kw., 2200-volt a.c. generator supplies power at the well, situated about two miles from the mill. The well pumps are electrically driven, of the vertical triplex type, provided with three 3-in. rams and 8-in. stroke and a working pressure of 450 lb. per sq.in. Special electrical equipment enables this installation to be controlled from the mill.

In addition to the plant as described, a complete Murex laboratory outfit is installed in the mill, to be used when the various ores are sent for experimental treatment by the Murex process.

The Murex system differs from all other processes as it is not necessary to produce those conditions in which the oiled mineral particles will float. Practically all other oil-concentration methods can be equally well made by the Murex process. In addition, certain separations can be made that previously have been considered impossible. Thus lead, zinc and copper carbonates containing sulphides can be concentrated from their various complex gangues. Blende and galena can be separated from heavy spar and from pyrite. In the cases of some ores it has been found that material of 2 or 3 mm. section can be treated successfully by this system, provided the mineral is freed from the gangues, and the latter can be eliminated in one opera-



PLANT OF THE DARWIN LEAD AND SILVER MINES AND DEVELOPMENT CO., AT DARWIN, CALIF.

tion, leaving the mineral values in such a form as to be easily smelted.

Various blends of oils, such as crude petroleum and residuum, are used in proportions of ¾% to 1¼% of oil per ton of ore to which is added equal quantities or more of ground magnetite. This mixture of oil and magnetite forms a permanent paint which, no matter how finely it may be divided or broken up, will always be found to be composed of the two substances in the same ratio.

Considerable skill is exercised in blending the various oil mixtures so as to make them amenable to each individual ore to be treated. The thickness of pulp,

MILLING AND MUREX-TREATMENT COSTS AT THE DARWIN PLANT OVER A PERIOD OF 30 DAYS

15 lb. oil @ 1.43 cents	$0.2145
17 lb. magnetite @ .20 cents	.2040
0.8 lb. olaic acid @ 15 cents	.1120
Labor three men @ $4.00	.7500
Power and water supply	.5000
Cost per ton	$1.7805

quantity of water and method of agitation are all important, particularly in cases of differential treatment, as in separating lead from zinc.

In the Murex process the ore need be ground only fine enough to free the mineral from the gangue. Both sands and slimes are treated together in one operation so that no classification is necessary, thereby reducing the crushing and running costs to a minimum.

The Phelps Dodge Concentrator at Morenci, Arizona

At the Morenci concentrator of the Phelps Dodge Corporation, at Morenci, Ariz., 14 cylindrical steel ore bins serve as storage for the run-of-mine ore. They are installed in parallel rows and have a combined capacity of 3000 tons. From these bins a belt conveyor carries the ore to the crushing plant, in which is installed a Gates No. 7½ gyratory machine, followed by three 48-in., horizontal, Symons disk crushers that reduce the ore to ¾-in. diameter. The crushing plant has a capacity of about 300 tons per hr. and is operated for one 8-hr. shift only each day. The dust is collected and drawn out of the crusher room by an electrically driven exhauster, thus making the department comfortable for men to work in.

From the crushing plant a belt conveyor carries the ore over an 18° incline, past a Blake-Denison weighing machine that records the weight of the ore passing up the belt, and this is checked by a Richardson measuring-type scale at the head of the conveyor. This conveyor delivers the ore to an automatic sampler, after which the general run of ore is distributed to the mill bins by a system of distributing belt conveyors. The mill is divided into two units, each having a capacity of 1000 tons, and both units draw ore from the same mill bin.

In each section the ore is fed by automatic plunger feeders to three Cole shaking screens, having 3½-mesh wire screen cloth. The oversize from these screens is sent to two sets of dry rolls. The material then passes into a closed circuit consisting of four wet Cole shaking screens and a pair of wet rolls, which reduces the entire product to 3½-mesh. The 3½-mesh product passes without classification to five Wilfley tables, equipped with Butchart riffles, which take out the first concentrates. The tailings from these Wilfleys are deslimed in a 6 x 20-ft. duplex Dorr classifier and pass to three 4 x 8-ft. Marathon mills, where the material is reduced to 48-mesh. The slimes overflow from the Dorr classifier is thickened in tanks with Dorr-thickener mechanisms. The thickened slime is then combined with the product of the Marathon mills and passes to a 4-ft. 6-in. by 15-ft. Dorr classifier, followed by two 6 x 20-ft. classifiers. The sands from these classifiers are treated on tables, the tailings going to waste. The overflow from the classifiers passes to flotation machines of the Rork type, and the flotation tailings are treated on Frue vanners. The flotation oils are added in the Marathon mills. This practice gives a rather poor oiling of the primary slimes, and experiments are being conducted with a view to securing better treatment of material of this class.

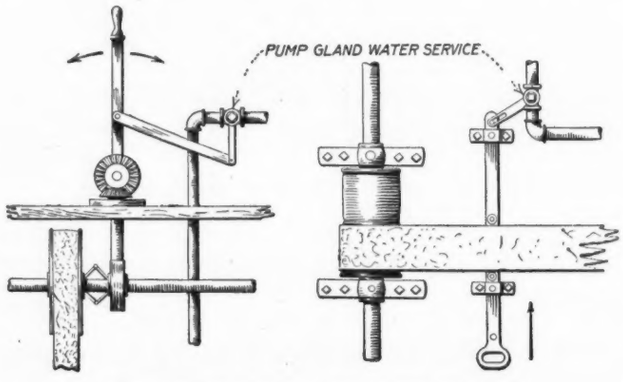
All table concentrates are dewatered in vacuum tanks, while the flotation concentrates pass to a 39-ft. Dorr thickener and are finally dewatered in a 14 x 14-ft. Oliver filter. All water from the concentrates is reclaimed, and all from the tailings except that which is necessary to transport them to the 14,000-ft. launder that conveys them to the tailings pond.

The recovery by gravity concentration amounts to practically 66% and that by flotation 10%, making a total of 76%. An efficiency of 12 tons per man-shift is obtained, and the plant operates about 95% of the time. The ratio of concentration is about 7:1; the water used is 510 gal. per ton of ore. Flotations concentrates average 19% copper, while the grade of the combined concentrates is about 12% copper per ton.

Clearance Water for Pump Glands

By A. W. Allen*

An automatic regulation of clearance water to the glands of centrifugal or plunger pumps handling sand or slime eliminates the personal element. Minimum of dilution is maintained, and the danger of scouring of



SUPPLYING WATER TO PUMP GLANDS

the shaft or plungers with gritty packing is avoided. The accompanying illustrations show how an automatic service may be arranged for intermittently running pumps of this description, that on the left showing the arrangement applicable to a pump using a clutch on driving shaft and that on the right being used with a tight and loose pulley drive.

*309 Broadway, New York.

Solution of Grinding Problems

By SERGIO BAGNARA
Mechanical engineer, Doe Run Lead Co., Rivermines, Mo.

The use of screen classifications as a basis for the construction of curves that may be used for purposes of comparison is a system that may be of service. The comparison of diagrams and curves will assist in estimating the value of grinding machinery.

IT is a matter of daily occurrence in milling practice that two or more curves of grinding have to be compared in order to get information, more or less useful, for the subsequent mill treatment of the pulps examined. The comparison consists often of the mere inspection of the two or more plots obtained and, unluckily much oftener, of two or more sets of figures referring to one or more of the sizes obtained. The information derived from this incomplete comparison gives by no means an idea of the absolute value of the curves.

In ball-mill grinding, especially when the curves are obtained from different types of machine, the information is still more incomplete and unreliable, since the

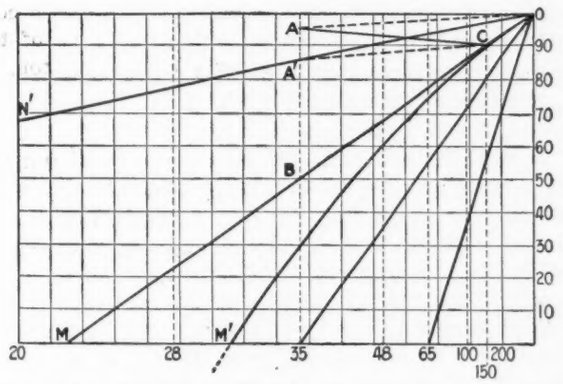


FIG. 1. EXPRESSING GRINDING CONDITIONS BY DIAGRAM

different plots are referred to one another and not to a standard representing an ideal curve of crushing or intended to represent the most convenient sizing obtainable under well-defined circumstances.

The question then arises: Is there any such curve, representing a sized pulp, that can be taken as the ideal curve, or the limit curve, or the curve of maximum efficiency?

Evidently, such a curve representing for each and every case a limit of grinding cannot be determined. The sizing of a pulp by grinding depends almost entirely on the ore and on the grinding device, the efficiency depends entirely on the milling operations after grinding, and both sizing and efficiency are intimately related to costs. It is, however, possible to determine the limit curve of grinding in each case with general methods that can easily be made to apply to any ore when the mineral-freeing value of the reduction is known.

The mathematical process for the determination of such a curve, as given here, refers to the disseminated lead ores of southeast Missouri, the grinding device considered being a well-known ball mill. The concentrating mill operates on three main classifications—the material between 9 and 2 mm. is treated by jigs, the coarse size between 2 mm. and 150-mesh is taken by tables, and all the minus 150-mesh is called slimes and sent to flotation, after being treated on slimes tables. It is the aim of the mill to make the least possible amount of slimes for both technological and economical reasons.

Assuming that the total extraction of the concentrating mill is to be brought to 90%, the ore must be ground in such a way as to have at least 90% of the lead as free-concentrating galena. By applying the laws of distribution of lead in these ores[1] it is easy to see that this condition is reached when all of it is ground to pass 100-mesh, or when the ore is perfectly sized between 65- and 200-mesh. By perfect sizing is meant classifying a pulp through a set of screens so as to leave on each one amounts proportional to the mesh opening of the screen. In other words, it is the size that is represented by a straight line in the cumulative direct plot of the ground pulp.

The perfect sizing from minus 65 is represented by the 0-65 line in Fig. 1. This line, however, does not satisfy the requirements of a line of good recovery, since it calls for 44.5% slimes (minus 150-mesh), nor does the 0-35 line, as it calls for over 20%, which is still objectionable.

From special crushing tests established, and described elsewhere, it appears that a theoretical minimum of 10% and a practical minimum of 12% slimes are obtainable on grinding our ores. According to the foregoing, a perfect sizing with 10% minus 150-mesh is the line *OM* cutting the 150 ordinate at the quota 90. The material represented by the line has evidently the disadvantage of being too coarse (50% minus 35-mesh), and since the amount of lead freed up to this size is only 65% of the total, additional grinding is necessary.

In order to make no alteration in the amount of slimes called for by this sizing—an amount that is an absolute minimum—the additional crushing has to be performed between the 35 and 150 ordinate only, and not beyond this ordinate. If we suppose that a fraction of the plus 35-mesh material has to be reduced, the diagram of additional grinding is evidently represented by the triangle *ACB*, point *C* being taken on the 150 ordinate and the *OM*. This additional grinding causes, theoretically, no variation of the amount of slimes, the triangle representing minimum grinding work permissible in the reduction of the fraction named.

Effect of Additional Grinding on Fines

Any additional grinding on coarse sizes will, however, affect the fines. In this case, by imposing the condition that the additional reduction shall be performed with the minimum expenditure of work, we may transform the diagram into another equivalent to it, extending the slimes line in such a way as to cause the minimum increase in the amount of slimes, since it is a diagram of minimum work. This transformation is indicated

by the elementary geometrical construction indicated on the figure. Diagram A^1BC will therefore represent a diagram of additional reduction with a minimum expenditure of work and consequently with a minimum increase in the slimes.

Let us extend the OA^1 to N. From what has been said, the line of sizing answering our purposes will be seen to be OM after the reduction represented by the diagram NOM. To find the final curve, let us suppose that the line OM is a perfectly elastic and prismatic system and let us apply to OM the work of reduction, considering it as a force. The diagram NOM will then be the diagram of curvature of the line sought. The problem is here geometrically indicated. The general equation of the curvature of any line is represented in differential terms by the equation,

$$\frac{1}{r} = \pm \frac{\frac{d^2y}{dx^2}}{\left[y + \left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}} \qquad (1)$$

which, neglecting the term $\left(\frac{dy}{dx}\right)^2$ becomes

$$\frac{1}{r} = \pm \frac{d^2y}{dx^2} \qquad (2)$$

From the figure we have $r = k\,x$ and with the position (3) $k' = 1/k$ the (2) in absolute values becomes

$$k' \frac{1}{x} = \frac{d^2y}{dx^2}$$

which, after two integrations, gives

$$k'\,x\,(log\,x - 1) = y \qquad (4)$$

where the logarithm is hyperbolic. This is the equation in finite terms of the limit curve. By means of convenient substitutions and ratings of variables it can be brought to the form

$$X\,Y = 1 \qquad (4^1)$$

which is the equation of an hyperbola of equal sides.

The curve (4) evidently touches the 0 point, since by making $y = 0$ it follows that $x = 0$. The value of k depends entirely on the fraction of plus 35-mesh to be reduced, and the fraction in itself is a function of the cost of making this additional grinding. The general expression of k is given by a consideration of triangles in the figure, and it is of the form,

$$k = cot\,A - cot\,B$$

which, after convenient substitutions, becomes

$$k = \frac{sin\,(A-B)}{sin\,A\,sin\,B} \qquad (5)$$

an expression that can be calculated by logarithms.

From the data of the problem it is clear that the fraction of plus 35-mesh to be ground affects only the value of k. For each variation of this fraction k will assume a definite value, K, and the new curve corresponding to this value is homothetic to the limit curve just found, and the ration of homothety will be k/K.

In the case represented in the figure where we are supposed to grind nine-tenths of the plus 35-mesh material the (5) gives $k = 3.333$ . . . which, remembering the position made in (3) gives

$$k^1 = 0.3$$

The general equation in finite terms (4) therefore becomes

$$y = 0.3\,x\,(log\,x - 1) \qquad (6)$$

and this curve was plotted in the figure. By making $y = 100$ the general expression (6) gives

$$333.3 = x\,(log\,x - 1) \qquad (6^1)$$

which resolved by the method of successive interpolation brings the "all pass point of the cumulative direct plot close to the 28-mesh ordinate. The numerical characteristics of this curve are:

NUMERICAL VALUES OF THE CURVE

28-mesh all pass	
On 35-mesh	29.3
On 48-mesh	60.5
On 65-mesh	75.0
On 100-mesh	84.7
On 150-mesh	88.8
On 200-mesh	91.5
Through 200-mesh	8.5
Total	100.0

In plotting this curve it should be borne in mind that the value given to the independent variable x must be measured on the scale of the dependent variable y in order to obtain the correct ordinate.

That the curve found answers the conditions imposed for a curve of maximum efficiency is easily understood if we consider that:

It is the curve obtained after two subsequent reductions, both graded according to a line of perfect grinding.

The additional reduction made on the OM is one that produces a minimum amount of slimes by the conditions imposed.

The work of additional reduction is a minimum, which is one of the conditions.

The grinding represented by this curve frees more lead as free galena than the milling can recover. This is immediately recognized through the laws of distribution of lead in our ores.

It is plain, however, that this curve could not be a limit curve in all cases or under different milling conditions. It is possible, though, to determine another curve for the same process by simply changing the conditions of the problem. This statement is under the assumption that the cumulative direct plot of any sizing is a continuous function of the size. The assumption is permissible if we suppose that the set of screens on which the sizing is done is composed of an infinite number of screens or, in other words, that the grains of crushed product differ from one another by an infinitesimal amount, which is confirmed in practice.

In Fig. 2 is represented a cumulative logarithmic plot of the curve according to the general expression (6). By applying to it the laws of distribution of lead[1], it is possible to trace a graphic of the lead freed as galena in grinding according to this curve. This graphic is also shown on the diagram, and both analytically and directly it shows that the limit curve would free 94.5% of the total lead. Of this, a little less than 85% would be taken by tables and about 10% sent to flotation, but as the slimes tables recover, say, 50% of the lead fed, the amount really sent to flotation would be about 5% of the total in the feed; only 5.6% would still remain combined with the rock as middlings or chat.

In order to exemplify the advantage of referring to a limit curve when making a comparison of different crushings, two more curves have been traced on the diagram. One represents a pulp discharged by a Marcy mill and the other a pulp obtained in grinding similar material through a Marathon mill. Comparing these

two curves with each other we can say that the Marcy grinds coarser on the coarse sizes and finer on the fine sizes than the Marathon, but which is the one that suits the milling exigencies best it is impossible to tell unless we refer both to the limit curve. By doing this, more features of each are revealed and an absolute value of the two curves obtained. In fact, it is easy to ascertain, for instance, that the tangent to the Marcy plot and the tangent to the limit curve on the 150-mesh ordinate are parallel. This means that the angle of contingency, and consequently the curvature, of both lines is identical at that point. This being also true in all the interval between 150 and 200, is shows that the Marcy mill has a minimum sliming capacity, this capacity being equal to that of the limit curve which stands to represent a minimum.

On the other hand, the sizing of the Marathon between 20- and 48-mesh runs in accordance with the sizing on the limit curve between 28 and 65. The two lines are congruent in the same vertical interval, and this means that a linear increase of reduction in the Marathon will give a pulp already sized according to the limit curve between 28 and 65.

The algebraic sum of the areas inclosed between each of the two curves and the limit curve—these areas being proportional to a work of grinding—is equal in each case. This means that the same amount of work is required in each case to bring the sizing to the limit curve. Conversely, because of the fact that the size of the feed was the same, it means that the Marcy requires a greater expenditure of work, or greater power consumption, than the Marathon in performing the same reduction.

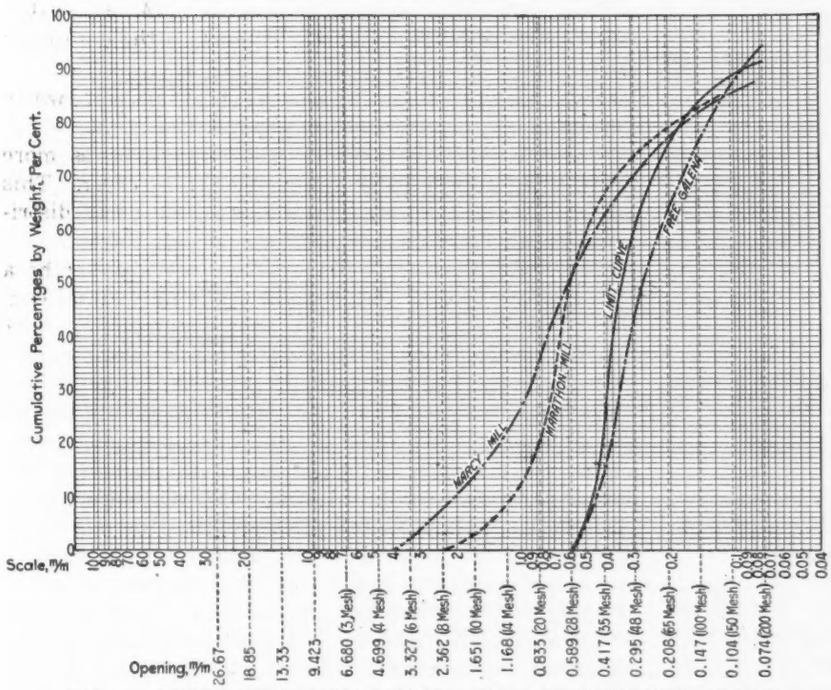


FIG. 2. CUMULATIVE LOGARITHMIC PLAT OF GRINDING CURVES

The use of the limit curve is of great advantage, and it should be determined by each mill. The minimum slimes possible to obtain under ideal conditions of grinding were ascertained according to the following considerations and with a very simple test designed to bring out typical conditions in grinding.

The slimes are due in crushing to two facts: First, the wearing action of the pieces either against one another or against the grinding device used; second, the separation of fine particles from the piece by blows that separate portions of the piece. If a piece of rock is crushed by hammering alone, the wearing action is eliminated and the amount of slimes obtained is a minimum.

A piece of rock was hammered on a steel plate in successive stages with the aim of obtaining a definite-sized product. At each stage both oversize and slimes (minus 150) were weighed and the slimes cumulated. Care was taken to hammer a piece at a time, and the results of different tests seem to agree fairly closely on 10 to 12% slimes for a grinding to pass 20-mesh. Of course this amount is entirely related to the amount of oversize obtained and of the reduction aimed at.

American Tube-Mill Pebbles

For a long time mill operators have been searching for a near-by source of pebbles for use in grinding mills, to take the place of those imported from Denmark, Norway, Sweden and France. The acute scarcity of the imported material during the last two years has led to increased activity in this search and has, apparently, produced some results. A rock formation about eight miles from Manhattan, Nev., is being exploited by Omer Maris. This rock is said to be a filled rhyolite of chalcedonous texture, and is extremely hard and tough. It occurs in layers 6 to 20 ft. thick, with occasional strata of unaltered rhyolite. The exploration has only reached a depth of about 30 feet. The rock is easily quarried and comes out in pieces without drilling, although occasional boulders, weighing a ton or more, have to be broken down by plastering or bulldozing. Usually the proper sizes are reached by breaking with hammers, and then given a vigorous tumbling treatment in a mill of the later type, whereby the pieces are brought to nearly spherical shape. They seem to reach this form more by a process of chipping than by wearing. The milling is done dry, only a little water being added to settle the dust. The pebbles produced resemble Norway flint and are said to wear about as well. Three mills in Manhattan and two in Tonopah are said to be using them and getting practically the same service out of them that was secured with the best imported pebbles. The material may prove to be of great importance at this time.

Mass Consolidated Mining Co.'s annual report for 1916 shows $94,556.03 spent in new construction, $730,811.94 in operating cost, and $194,634 in dividends. The income from 4,752,588 lb. of copper and 1812.5 oz. of silver, together with accrued interest, was $1,255,895.92. The balance of cash asset is given as $449,255.02 as at Dec. 31, 1916, compared with $213,361.07 at the end of the previous year. Labor cost has shown an increase of 18% over 1915 and supplies a corresponding increase.

Selective Lead-Zinc Flotation

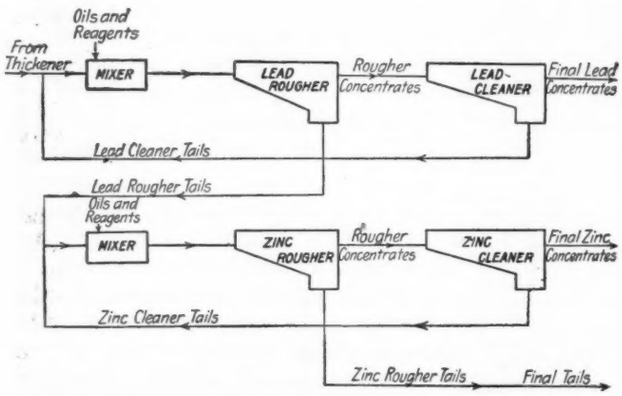
By LUTHER L. KIRTLEY*

Experiment in solving the problem of recovering zinc and lead separately from the zinc-lead slimes led to the selection of oil flotation as the best method. Various oils were tried and various methods, the one ultimately selected combining in itself most of the advantages.

ABOUT a year ago, when I received the commission of working out a method for treating the slimes of a lead-zinc concentrator by flotation, I turned to the technical journals for suggestions. I was unable to get much help from them at that time and, indeed, but little has appeared during the last year. So I feel that perhaps a recounting of some of my troubles and their solution may be of assistance to others who are trying similar work.

Separating Lead and Zinc Concentrates from Slimes

The problem was to take for heads, the slimes that would ordinarily be treated on slimes tables, or perhaps the tailings from such tables, and produce by flotation alone, without the aid of tables, lead concentrates low



FLOW SHEET OF THE SELECTIVE PROCESS

in zinc and zinc concentrates low in lead. The slimes would assay on the average 6% lead and 8% zinc. The maximum percentage of zinc in the lead concentrates that the lead smelter would allow was 15%, and the minimum percentage of zinc that the zinc smelter would accept in the zinc concentrates was 30%.

In order to get high-grade zinc concentrates, it was thought necessary to remove practically all of the lead before attempting to float the zinc, a conclusion that was borne out by the experiments. This condition divided the problem into two natural parts: (1) To get lead concentrates low in zinc, with tailings as low in lead as possible, and (2) to get zinc concentrates high in zinc and with as low zinc tailings as possible.

From the descriptions of the work at the Missouri School of Mines, it appeared that a good oil for lead is hardwood creosote and that a good example of such an oil is Cleveland Cliffs No. 2. Experiments proved that this is a good oil for lead, but that it brings up considerable zinc too. In order to keep the zinc down, the conditions were varied, and it was found that in an alkaline solution the zinc content of the concentrates was fairly low and that sodium carbonate was the best reagent.

In all these tests the dilution of the sample was between 15% and 20% solids, and the temperature was the same as that of the mill water. The oil was added at the rate of 2 lb. per ton of dry slimes in each case.

RECORD OF TESTS USING HARDWOOD CREOSOTE

C.C. No. 2. No reagent	Pb	SiO_2	Zn	Extraction % Pb	Extraction % Zn
Head	5.0	....	7.6	....	....
Concentrates	19.3	38.1	12.3	55.4	22.3
Tailings	2.6	....	7.2	....	....
C.C. No. 2. Reagent—H_2SO_4 2 lb. per ton					
Head	7.4	....	10.4	....	....
Concentrates	20.0	32.0	13.8	71.1	37.5
Tailings	2.9	....	8.2	....	....
C.C. No. 2. Reagent—NaOH 2 lb. per ton					
Head	6.0	....	9.2	....	....
Concentrates	17.4	37.0	11.5	63.5	29.5
Tailings	2.8	....	8.2	....	....
C.C. No. 2. Reagent—Na_2CO_3 2 lb. per ton					
Head	6.0	....	7.5	....	....
Concentrates	11.4	49.0	7.9	66.3	47.4
Tailings	3.1	....	7.0	....	....

From this series of tests it was concluded to apply the conditions used in test No. 4 and to go ahead with the problem of bringing up the zinc. After quite a large number of tests I found that a fuel oil called Texana No. 7, or No. 8 seemed to film the blende with oil in a satisfactory manner and that Georgia pine turpentine No. 205 (which is a mixture of crude pine oil, crude wood turpentine and "heavy products") worked well as a frother. Pensacola pine turpentine No. 350 (which is a crude pinewood oil) and also General Naval Stores No. 17 (which is a crude hardwood oil) worked well as frothers, but as the sample of the Georgia product was in better shape than the others, I used it in most of the tests.

I soon found that the hard part of the work with zinc was to get low tailings and that increasing the amount of oil above 2 lb. per ton failed to solve the difficulty. Sulphuric acid not only failed to give low tailings, but also produced dirty concentrates. About this time J. M. Callow described some of his methods, and one of them was the use of small amounts of copper sulphate to secure low zinc tailings. I found that by using it at the rate of ½ lb. per ton, I made satisfactory tailings. Copper sulphate was also tried in the lead run and found to be quite a help in securing low lead tailings if used in amounts under ¼ lb. per ton.

In all these tests the iron content of the concentrates was about 8%. The different oils seemed to bring up about the same amount of iron under all the conditions. Sodium sulphide, when present in amounts over 5 lb. per ton brought up the iron at a lively rate, but when present in amounts of about 1 lb. per ton, served to bring up additional zinc. This action is especially noticeable if the sulphide is added after most of the concentrates have come over and the effect of the oil has begun to diminish. These last concentrates have considerably less silica, strangely enough, and are frequently high in grade.

In these tests the conditions were the same as those in the lead tests. The mixture of oils was added at

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the rate of 2 lb. per ton. The proportion of the two oils varied between 50-50 and 80-20%, with the fuel oil always in excess.

In making the cleaning tests to raise the grade of the concentrates, it was necessary to add some sodium carbonate to the lead concentrates, but the addition of copper sulphate did more harm than good. Without the copper sulphate the zinc content of the cleaner concentrates was about the same as that of the rougher concentrates, but with it the zinc seemed to come up at the same rate as the lead. In cleaning the zinc concentrates the addition of reagents seemed to be of no help. In all cleaning tests the addition of oil was quite unnecessary.

In making the tests, both the Minerals Separation type and the Callow type of machine was used. The latter seemed to give lower tailings than the Minerals Separation type, and concentrates that were broken down easily and easily cleaned as well, although the silica content was higher than that of the Minnerals Separation machine product. The selective action of the oils and reagents seemed to be more pronounced in the Callow type, especially in lead tests.

FLOTATION TESTS USING FUEL OIL

	Pb	SiO_2	Zn	Extraction % Pb	Extraction % Zn
Texana No. 8, Georgia No. 205. Reagent—Na_2S 2 lb. per ton					
Head	2.4	....	6.0	....	....
Concentrates	11.8	24.0	26.4	....	72.1
Tailings	0.3	....	2.0	....	....
Texana No. 8, Georgia No. 205. Reagent—$CuSO_4$ ½ lb. per ton					
Head	0.8	....	4.9	....	....
Concentrates	11.8	32.0	20.9	....	71.0
Tailings	0.2	....	1.7	....	....
Texana No. 8, Georgia No. 205. Reagent—$CuSO_4$ ½ lb. per ton, Na_2S 2 lb. per ton					
Head	3.0	....	6.8	....	....
Concentrates	12.9	24.0	24.0	....	81.6
Tailings	0.2	....	1.7	....	....

At one time I was short of tubs in which to catch the slimes samples, and in lieu of anything better at hand I used tubs made by cutting an old oil barrel in half. There was enough oil left in the wood of the barrel to introduce some into the sample, and it practically destroyed the selective action. After that, I was careful to use only the galvanized iron tubs for the samples.

During the winter months the oils became cold and stiff and hard to handle. To correct this difficulty I made a little iron shelf on a steam radiator upon which I could place the samples of oil and get them fluid again. Soon I formed the habit of leaving the oils on the hot plate for longer and longer periods, and finally for perhaps a week at a time. About this time the results were not satisfactory, and I wondered if the constant cooking had removed some of the volatile constituents of the oils. Fresh samples of oil showed that this was exactly what had happened, for with the fresh oils the results were considerably better.

As there was but one machine of each type, I had to use the same machine for both the lead and the zinc runs. The lead content of the zinc concentrates seemed to be the same in cases where the lead tailings were very low as where the lead tailings were not so good. Of course the machine was being cleaned out each time between the lead and the zinc runs, but it was only after fairly flushing out with a quantity of water that the results became more consistent.

The samples in these tests weighed between 15 lb. and 20 lb., which gave products too large to dry and weigh direct. In order to figure the extractions, I needed a formula involving four variables, corresponding to (1) heads, (2) lead concentrates, (3) zinc concentrates, (4) tailings. Inasmuch as such an expression seemed unprocurable, I used Gahl's formula,

$$E = \frac{c(f-t)}{f(c-t)}$$

as described in the *Journal* of Apr. 1, 1916. To adapt this formula to the conditions, I took a sample of the pulp after the lead concentrates had come off, which was called the lead tailings, and enabled me to compute the extraction of the lead. Then by renaming the same sample "zinc heads" and taking a sample after the zinc concentrates had come off, which was zinc tailings, it was possible to figure the zinc extraction.

In order to determine the weight of dry slime in the wet sample I used the formula,

$$X = \frac{Sp.Gr.}{Sp.Gr.-1} W - F$$

which is the same as

$$W = \frac{Sp.Gr.-1}{Sp.Gr.} + F$$

where F is the weight of water in a given flask, W is the weight of the slimes sample in the same flask, and $Sp.Gr.$ is the specific gravity of the dry slimes.

The flask used was a 5-lb. acid bottle, which served two purposes—it gave a sample for assay and also gave the weight of the dry slimes in the bottle. By measuring the volume of the flotation machine with reference to that of the acid bottle, it was easy to determine the weight of slime in the machine.

The final results, showing the effect of cleaning tests, as noted in the table, are actual results and are averages of seven roughing tests the products of which were combined to make one cleaning test.

RESULTS OF CLEANING TESTS

	Pb	SiO_2	Zn
Average head assay	7.0	....	7.8
Average rougher lead concentrates	23.8	32.5	12.5
Average rougher zinc concentrates	14.4	23.9	24.3
Average rougher zinc tailings	0.7	....	2.8
Cleaner lead concentrates	35.8	21.4	12.4
Cleaner zinc concentrates	16.2	14.2	29.3
Extractions:			
Rougher zinc tailings	6.8%	....	23.8%
Cleaner lead concentrates	58.3%	....	18.1%
Cleaner zinc concentrates	27.1%	....	43.7%

In the foregoing examples, it will be noticed that the grade of the zinc concentrates has not been raised much. The assay of the cleaner zinc concentrates is the average from several samples taken during the cleaner test, the first of which was about 35% and the last about 27% Zn. By making the zinc cleaner test shorter, the grade of the product can be raised to 33% or 35% without any bad effects.

The effect of circulating the cleaner tailings back to the rougher cell seems to be beneficial rather than harmful. By doing this a thoroughly emulsified oil is introduced, which not only helps to get good results, but also cuts down the consumption of fresh oil.

As may be seen in the flow-sheet diagram, there are two separate circuits. This is necessary to the success of the scheme, for if the rougher zinc tailings were circulated back to the head of the lead machine, they would introduce into that machine oils that would bring up a large percentage of zinc and thus upset the selective action. Not only would the wrong oils be introduced, but also wrong reagents, and thus wrong

conditions would obtain, so that probably the resulting concentrates would contain as much zinc as lead, if not more.

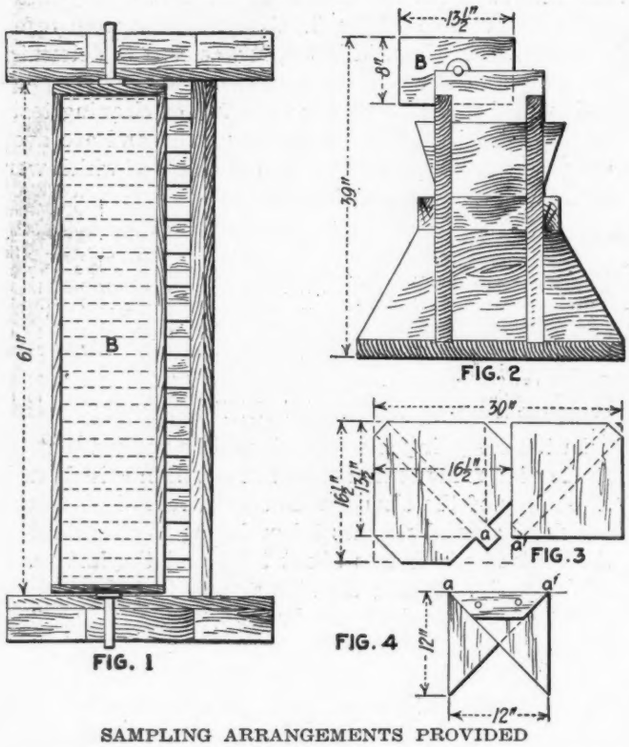
The mixer between the lead and zinc machines is necessary, since the heavy fuel oil used as the collector for the zinc requires thorough mixing, even more than the oil for the lead.

From the results secured it can be seen that it is possible to produce by flotation alone salable products from lead and zinc slimes. That such a system would be delicate goes without saying, for even in plants where simple systems are in operation, requiring little circulation, conditions vary a great deal at times and occasionally entirely destroy the flotation action. The results cited are not selected in any sense, but are the actual averages of results secured from samples taken from the mill under all operating conditions, and therefore I feel confident that such a system, under careful and close supervision, would prove a commercial success.

Ore Sampling at a Custom Mill

BY JACKSON A. PEARCE*

Buying ore for a custom mill in a superannuated district is not an enviable avocation. This is especially true where decades of imposition on the part of ore buyers have developed a suspicious public. The Argo mill is one of several operating exclusively on custom ore.



SAMPLING ARRANGEMENTS PROVIDED

To allay the suspicion so deeply rooted in the district, we have endeavored to maintain a sampler free from the possibility of manipulating to our advantage.

The prevalent Western custom of sampling ore is to crush and pile the entire lot and shovel it over, setting aside every tenth shovel for coning and quartering. The possibility of error, intentional or otherwise, in this system is evident to one familiar with it. Instead of removing a tenth by shovel, we remove a fourth from a continuous stream of ore by means of a Snyder sampler. This operation is twice repeated automatically and continuously, the ore being crushed finer in each operation. A final sample of from 500 to 4000 lb. results. It has been customary with us to reduce this sample by the cone-and-quarter method. This method is open to serious error, as has been pointed out by the Bureau of Mines, and further, it is possible for an expert sampler to juggle the sampling, as has been pointed out by most of the shippers. To eliminate this objectionable feature, we have installed a cutter of the Jones, or Brunton, type. There is nothing particularly new in it except that it is larger than usual. This makes a sampler flow sheet as nearly free from manipulation as possible. It has gained the confidence of the shipper to an extent greater than anticipated. Whereas, formerly about 10% of the lots were resampled, only one has been resampled in the last 250 lots.

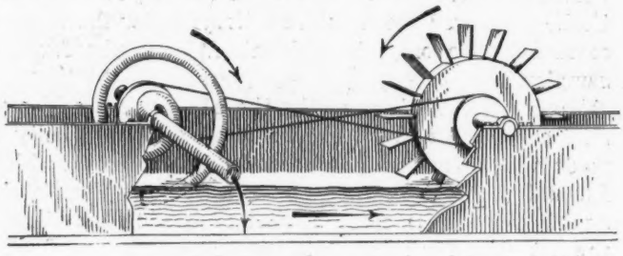
Fig. 1 is a plan of the cutter and Fig. 2 an end section. A box *B*, with a capacity of 200 to 250 lb., is filled, leveled and emptied upon the cutter. The operation is repeated until the sample is small enough to be handled on smaller cutters.

The sampler was made by the men at the plant. No. 18 iron was found suitable for the cutting arrangement. Fig. 3 shows the method of cutting a piece of 30-in. sheet iron. If cut along the solid lines and bent along the broken lines, the two resulting pieces may be bolted or riveted together, as shown in Fig. 4. Projections, *a* and *a'*, fasten it rigidly to the framework.

An Automatic Sampler

BY A. W. ALLEN*

The apparatus illustrated herewith is well suited for sampling thin slime pulp or solution and can be adjusted in a way permitting a representative sample to



AUTOMATIC PULP SAMPLER

be taken of any particular volume. The sample is delivered at a point above the level of the launder through a pipe bent in the manner shown, which also acts as a shaft supporting the sampler. The distance between sampler and waterwheel should be adjustable.

Shattuck Arizona Copper Co., of Bisbee, Ariz., reports that during 1916, 183,538 tons of ore was mined and 183,968 tons smelted for the total recovery of 18,161,763 lb. Cu, 4721 oz. Au, 314,918 oz. Ag and 3,413,445 lb. Pb, an average recovery of 5.384% Cu, 0.028 oz. Au and 1.867 oz. Ag per ton of copper ore, and 16.85% Pb, 0.165 oz. Au and 4.759 oz. Ag per ton of lead ore treated, the copper sold amounting to 17,308,670 lb. averaging 23.18c. per lb. Net profits for the year were $3,074,012, and four regular and four extra dividends amounting to $1,662,500 were paid.

*Idaho Springs, Colo.

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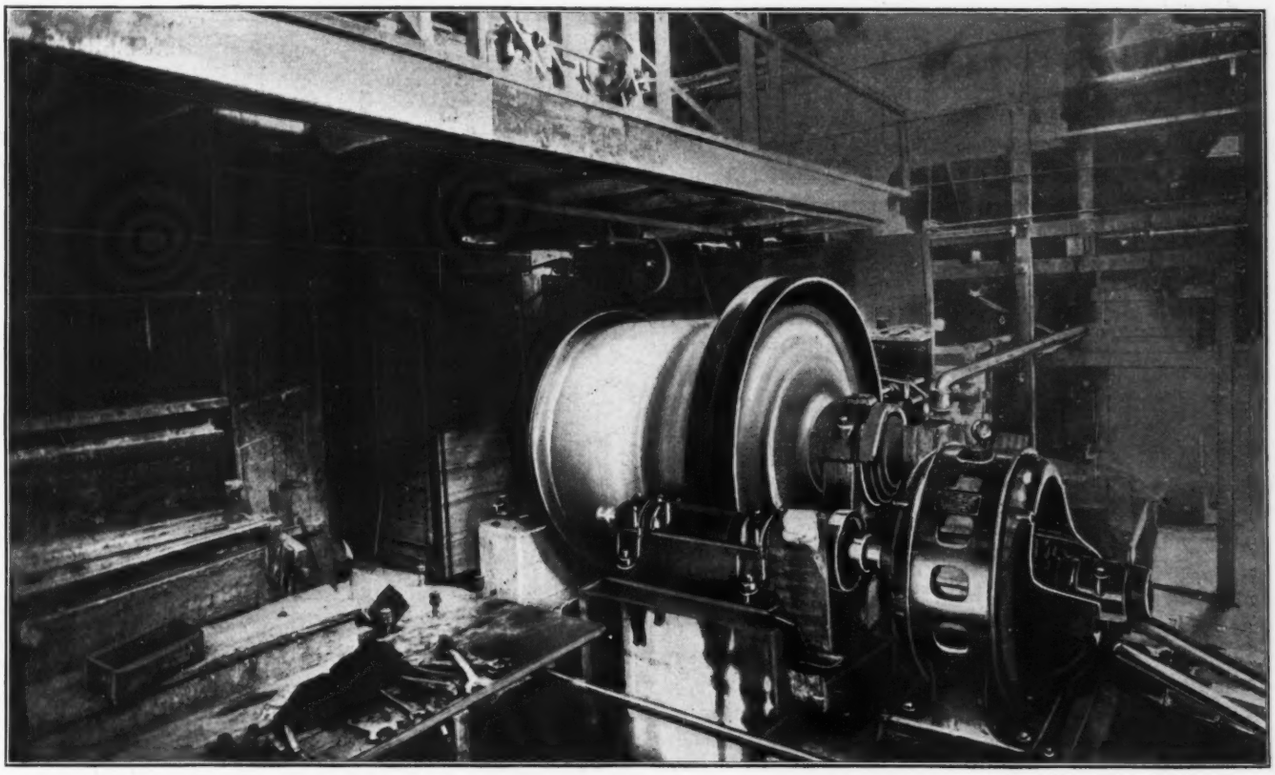
The Tom Reed Mill, Oatman, Ariz.

By H. P. FLINT
Mill Superintendent for the Tom Reed Gold Mines Co.

A description of the new cyanide mill of the Tom Reed Gold Mines Co., Oatman, Ariz., built to double the capacity of the one formerly in use. Ball-mill crushing is practiced, and agitation of slimes is by Dorr agitators. The mill crew has been reduced from five on a shift to two.

RESULTS of investigations made last fall by the board of directors of the Tom Reed Gold Mines Co. showed them that their mill and cyanide plant was too small and inefficient to treat profitably the grade of ore developed in the mine. In order to show satisfactory earnings on this ore it was deemed necessary to increase not only the efficiency of the mill, but also the tonnage treated. The management was then ordered not only to submit plans and estimates to double the mill capacity, using the old mill site, but to utilize as much of the old equipment as possible. Plans and estimates were submitted and accepted. They were authorized and ordered by the board of directors to be installed immediately. This new installation was designed and constructed by E. M. Rabb, manager of the company's property, and H. P. Flint, mill superintendent. The construction program was carried out and the new mill started operating without loss of time or any interference with operations of the old mill. Five months was consumed in the construction of the mill.



A PARTIAL VIEW OF THE INTERIOR OF THE TOM REED MILL, AT OATMAN, ARIZ.

The ore is delivered from the mine bin to an Austin No. 2 gyratory and a 15 x 22-in. Dodge crusher, breaking to a maximum of 2½-in. The crushed ore is discharged upon an inclined-belt conveyor that elevates it to the mill bin. This bin was enlarged by adding 8 ft. to the height of the old bin and extending it in length 8 ft. and also altering the last 14 ft. of the old bin from a 45° incline to a flat bottom.

A 16 x 16-in. steel chute was set in the bottom of this bin to deliver the ore to a 24-in. x 5-ft. Stephens-Adamson apron feeder. This feeder is driven and controlled through a No. 1 Reeves variable-speed transmission machine, having a range of adjustment of two to one. This machine is giving a very satisfactory control of feed.

The apron feeder delivers the ore to a combination scoop feeder (42-in. radius) of an Allis-Chalmers 6 x 5-ft. ball granulator, direct-driven by a 100-hp. slip-ring motor through Wuest herringbone gear and pinion. The coupling is of the bushing type. This mill is used as the primary grinder, with 5-in. chrome-steel balls, and is in closed circuit with one Dorr duplex classifier. The mill is lined with step-type manganese-steel lining.

The pulp overflow from the primary classifier flows by gravity to two pairs of similar classifiers on the floor below, each pair of which is in closed circuit with an Allis-Chalmers 5 x 6-ft. ball granulator used for finishing. Each of these mills is driven by a 75-hp. slip-ring motor through a Wuest herringbone gear and pinion and a bushing-type coupling. The ball feed to these mills is 1½-in. chrome steel; the liners are of the step type

and are also of chrome steel. These two mills are provided with 42-in. radius, combination scoop feeders.

The primary classifier, the Reeves machine and apron feeder are driven by a 5-hp. motor; the few secondary classifiers are driven by another 5-hp. motor.

All the switches and starting equipment are placed together on a central switchboard within easy reach of the operator and commanding a view of all the machinery. The starters for the three ball granulators are provided with ammeters to facilitate load control on the mills.

The finished product from the two pairs of secondary classifiers flows by gravity to an 11.5 x 40-ft. redwood tank equipped with Dorr thickener, machinery driven by a 3-hp. motor provided with an ammeter, which normally registers 1.7 amperes. A minimum of 85% through 200-mesh screen is required and obtained in the finished product.

The Thickeners and Agitators

From this primary thickener the pulp, at a specific gravity of 1.48 to 1.50, is transferred by a 4-in. air lift to the first of a series of four 11.5 x 40-ft. redwood tanks equipped with Dorr agitating machinery. These tanks are connected by 4-in. pipes placed on a 45° slope from the preceeding to the following tank. These agitators are driven by individual 3-hp. motors with ammeters on each to enable the attendant to note any overload, and normally pull 2.4 to 2.5 amperes each.

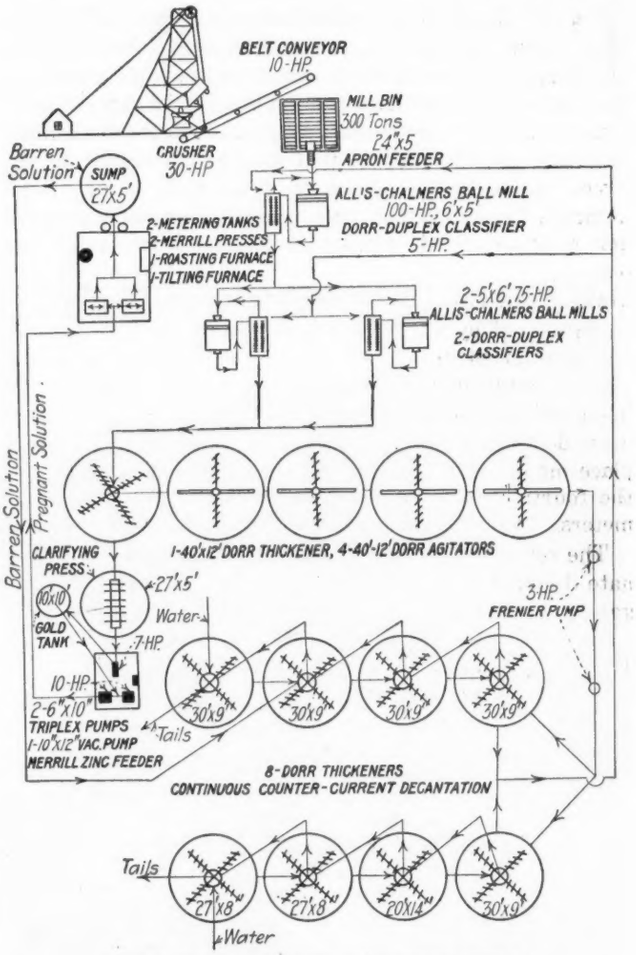
The four agitators replace four 10 x 38-ft. Pachuca or Brown agitators and give approximately twice the period of contact under double the duty required of the Pachucas, and show by results obtained 50% more efficiency when handling a sandy pulp.

From the last Dorr agitator the pulp is elevated by a 4-in. air lift to the lower of two 10 x 54-in. Frenier pumps, each driven by a 2-hp. motor geared to the pump. The lower pump delivers to the upper and this in turn to a distributing box. From this distributing box the pulp is divided between the head tanks of two series of four 9 x 30-ft. steel tanks equipped with Dorr thickener machinery operating on the counter-current decantation system. Each thickener is driven by a 3-hp. motor provided with an ammeter to indicate the load. The elevation of the pulp to the decantation tanks is necessitated by the fact that these tanks were part of the old installation and are and always have been above the grinding machinery.

The pulp discharge from each of the decantation thickeners is elevated to mixing boxes, where it meets the overflow solution from the second succeeding thickener and is discharged into the first succeeding thickener, and so on throughout the series. These decantation thickeners are being equipped with distributing launders made of 3-in. pipe, perforated at regular intervals along the bottoms and slotted on top to facilitate cleaning, it having been found by experiment that this does not interfere with the clarifying action and, further, gives an almost perfect mixture of solution throughout the tank. The overflow and discharge solutions show practically the same values for any given thickener, provided extraction is complete in the agitators. This is the case with the new installation.

The residues discharged from the last of each series of decantation thickeners pass over an automatic sampler and into a system of distributing pipes. These pipes lead out over the various sections of the tailings pond to facilitate the even distribution of tailings on each section of the pond in layers of proper thickness for "farming." The scrapings from these ponds are hauled by a Jeffery "quad" truck and delivered to the ore bin for re-treatment. The recovery from these scrapings is offset against the tailings loss each year.

The overflow solution from the head tanks of the two decantation series flows direct to the ball mills and classifiers, whence it passes to the primary thickener. The overflowing pregnant solution from the primary thickener passes to a 5 x 27-ft. steel sump tank in which



FLOW SHEET OF THE TOM REED MILL

are suspended forty-four 3 x 9-ft. filter leaves connected to the suction of a 12 x 10-in. Goulds vacuum pump. This pump discharges into a 10 x 10-ft. redwood sump that is connected to the suction of two 6½ x 10-in. Rumsey triplex pumps. These pumps are direct-driven by a 10-hp. motor each, one of which is always in reserve.

Precipitation by Zinc Dust

Zinc dust is here added to the clarified solution by a Merrill zinc feeder and emulsifier through a 4-in. standpipe connected to the common suction of the pumps. These pumps lift the solution through two Merrill 300-ton precipitating presses situated in the refinery 45 ft. above the pumps. The amount of solution required by the emulsifier is drawn from the discharge of the pre-

cipitating pumps between the pumps and a check valve in the discharge line. The feeder and emulsifier are driven from the jackshaft of the pump that happens to be in commission. This arrangement relieves the attendant of the necessity of opening or closing valves or stopping or starting any separate machinery when the precipitating pump is stopped or started.

The rearrangement of the plant has permitted the discarding of two battery-solution pumps elevating 1000 tons of solution 45 ft; two 8 x 52-in. Frenier pumps which operated in closed circuit with the old tube mills and classifiers; one 4-in. Butters and two 2-in. Hansen centrifugal pumps which elevated 1200 tons of solution and 150 tons of crushed ore through 32-ft. vertical lift; one 2½-in. Hansen centrifugal pump, used intermittently to clean out the Pachuca agitators; one 6½ x 10-in. Rumsey triplex pump, used to return precipitated solution to the barren solution tank 100 ft. above the pump; three other minor pumps and one small Goulds vacuum pump.

From the Merrill zinc presses the precipitated solution flows by gravity to two 6 x 6-ft. alternating measuring tanks. The solution flows through a tilting launder operated by two floats. This launder in turn opens one and closes the other of the discharge valves of these tanks. The rise and fall of the solution in each tank is registered by Bristol water-level recording gages.

The solution discharges from these measuring tanks into a barren-solution 5 x 27-ft. steel tank. From this sump the barren solution is piped to the third tank in each decantation series. The water necessary to replace moisture discharged with the tailings is added to the fourth tank of each series through two 1-in. water meters. Water for the mill is obtained from the mine.

The refinery is placed at the top of the plant to eliminate duplication of pumping. It is housed in a corrugated-iron building 22 x 30 ft., having 10-ft. walls and a ventilator the full length of the building on the gable. The two precipitating presses are ranged along one side with the spigots toward the wall, while on the other side are two roasting muffles and a Steele-Harvey, No. 150, tilting furnace.

The mill is at present operated by a regular crew of two men on a shift as against a regular crew of five men formerly employed.

To Find the Length of a Leather Belt by Weighing*

Put the belt on a pair of scales, get the correct weight, measure the thickness and width, and then lay the ruler across this chart twice and column *E* will tell the length in feet in a jiffy. The belt need not be rolled up neatly; it can be a jumbled up mess, as belts sometimes are, yet the scales will not lie. There is nothing miraculous about this method. It is based on the fact that leather belting weighs 0.035 lb. per cubic inch. So, knowing the width and thickness one can solve "backward" for the length. This chart, however, does away with the figuring.

For example, What is the length of a belt whose thickness is ¼ in., whose weight is 42 lb., and whose width is 10 inches?

Connect the ¼ (column *A*) with the 42 (column *C*) and extend the line to intersect column *D* as indicated by the dotted lines. Then run a line through that intersection and the 10 (column *B*), and the intersection with column *E* gives the answer as 40 ft. as the length of the belting in the rod.

When measuring the thickness of a belt, it is well to use considerable care, since a fractional part of an inch on this chart will make a great difference in the answer, as you may readily observe. If the belt is rolled up,

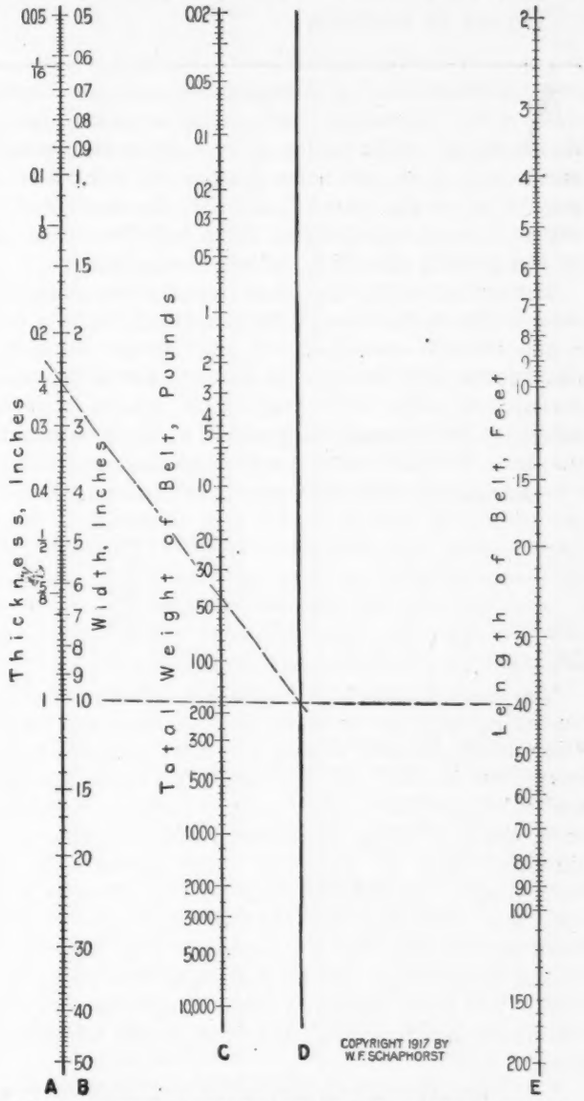


CHART TO FIND LENGTH OF LEATHER BELT WHEN WEIGHT IS KNOWN

measure the total thickness of ten layers. It is then easy to divide by 10. For example, if you find the total thickness of ten layers to be 2⅜ in., you know that to equal 2.375 in. Dividing by 10, the thickness of the belt is therefore 0.2375 in. You could not do much better with a pair of micrometer calipers even if it were considered desirable to do so.

The range of this chart is great enough to include all ordinary and many extraordinary belts. It is of service in a great number of instances where it would be exceedingly inconvenient to unroll the whole package of belting and put a tape line on it. Besides, no great amount of room is required to perform the operation.

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Concentration at Humboldt, Arizona

BY GEORGE M. COLVOCORESSES
General Manager, Consolidated Arizona Smelting Co., Humboldt, Ariz.

Treatment at the Consolidated Arizona Smelting Co.'s plant is complicated by the variety of the ore, its hardness and the difference in various grades. Concentration, oil flotation and smelting are all practiced.

ALTHOUGH the Consolidated Arizona Smelting Co. of Humboldt, Yavapai County, Ariz., has conducted concentration of ores on a comparatively small scale, there are some features of this work that may be of general interest, and it is the purpose of this article to treat especially of these features rather than of the general operations of ore concentration.

The concentrating ore comes from the two mines operated by the company—the Blue Bell and De Soto mines—and consists essentially of an intimate mixture of chalcopyrite and iron pyrites in a gangue of quartz and sericite, chlorite and hornblende schists (Yavapai schist). The average composition of the concentrating ore from the two mines is approximately as follows:

AVERAGE COMPOSITION OF CONCENTRATING ORES

	Bluebell	Desoto
Au	0.035 oz.	0.03 oz.
Ag	1.40 oz.	1.30 oz.
Cu	3.20%	3.20%
Fe	15.00%	9.00%
S	17.00%	10.00%
CaO	1.00%	2.00%
MgO	1.00%	1.50%
Al_2O_3	4.00%	4.50%
SiO_2	57.00%	69.00%

The concentrator building was erected in 1905, intended at that time to treat only ore from the De Soto mine, which (as will be noted) is more siliceous, but the operations in 1905 and 1906 were not at all successful and only about 50% of the copper contents were recovered, the mill being closed down after treating a few thousand tons of material. The concentrator was started again in 1913, at which time the Blue Bell mine only was producing and 68% of the copper contents were recovered in the concentrator. Flotation was installed in 1914, and the De Soto mine was reopened in 1915. The main results of the concentrator operations during the last four years are given in the table following:

RESULTS OF CONCENTRATOR OPERATIONS

Year	1913	1914	1915	1916
Tons of ore treated	30,635*	53,906	81,544	80,304
Average Au contents of ore treated, oz. per ton	0.08	0.0355	0.034	0.036
Average Ag contents of ore treated, oz. per ton	1.66	1.233	1.05	1.07
Average Cu contents of ore treated, %	3.70	3.504	2.83	3.19
Tons of Con. produced	10,462	12,281	19,877	24,514
Recovery of Au in conc., %	51.28	55.55	62.50	80.30
Recovery of Ag in conc., %	49.94	59.15	70.50	79.90
Recovery of Cu in conc., %	67.59	78.12	88.60	92.50
Ratio of concentration	2.93:1	4.29:1	4.1:1	3.28:1

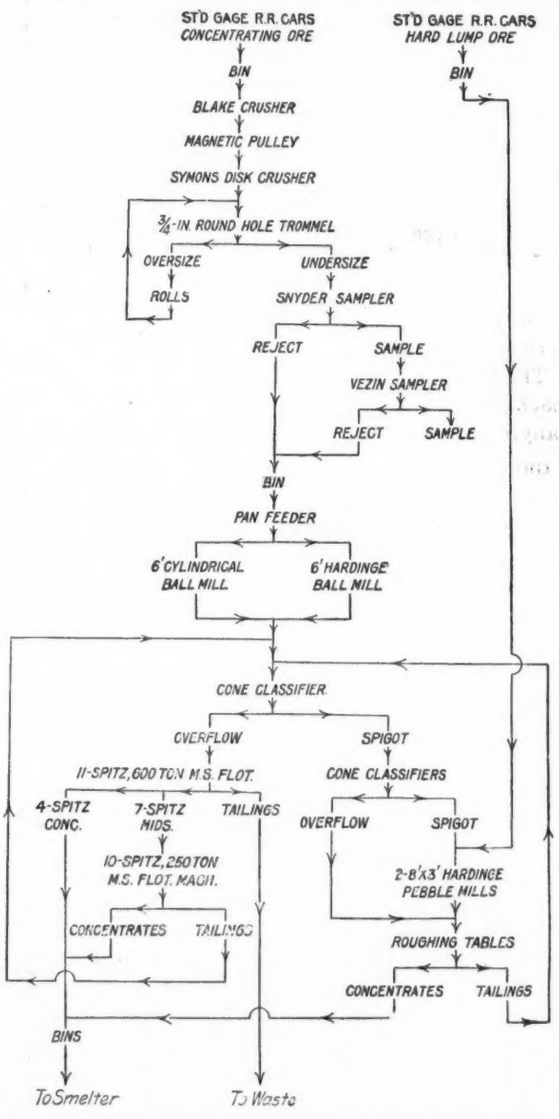
* Includes 1,603 tons of Fennell ore with high gold values.

During 1915 and 1916 a certain amount of tailings from the old operations of the concentrator, averaging 1.75% copper, were treated and this reduced the average grade of mill heads and also tended to reduce the recovery of metals since the copper in the tailings is more or less oxidized and does not float as readily as the fresh ore from the mines.

During the latter part of 1916 and the beginning of 1917, new equipment was placed in the concentrator, and at present approximately 400 tons of ore is being treated daily with the expectation of treating between 500 and 600 tons in the near future as adjustments are made to the crushing equipment. The flow sheet of the concentrator has been altered and modified several times during the last four years and at present is represented by the accompanying diagram.

Some of the points that may be of special interest in connection with our concentrating operations are treated under the following headings.

Although for certain ores it is undoubtedly advantageous to take out as much mineral as possible in the



FLOW SHEET OF THE CONSOLIDATED ARIZONA SMELTING CO.'S MILL

form of a coarse product, an attempt to carry out this program has not been satisfactory at Humboldt. The minerals in the ore are intimately mixed with the gangue, and experience has proved that there is no thorough separation of the minerals and gangue until very fine grinding has taken place and until the particles of

ore have been reduced to pass 65-mesh or, better, to pass even 100-mesh. During 1913 and 1914 we operated jigs, the feed having been crushed to pass ½ in., but the jig concentrates were extremely low in grade and the jigs served mainly to remove the coarse pieces of rock as well as ore and, naturally, took out more iron pyrites than copper pyrites. It soon became apparent that the jigs could be eliminated altogether with advantage. After the jigs were removed, all the feed was crushed to pass 10-mesh and a table product was made, and at present the table feed will practically all pass 20-mesh.

As the concentrator is now arranged, the discharge from the ball mills is classified and the overflow goes direct to the flotation machine, while the coarse material is sent to the two 8-ft. Hardinge pebble mills. The discharge from the pebble mills goes over the roughing tables, and the tails from the tables are returned to the classifier in closed circuit. The roughing table concentrates contain about 4.50% copper, 15% insoluble and 38% iron. This product constitutes about 60% by weight of the mill concentrates, but contains only about 30% of the copper recovered, so that even at this stage we still recover a far larger proportion of iron than copper.

The average flotation concentrates contain about 15% copper, 20% of insoluble and 25% iron, and the mixture of the flotation concentrates and the table concentrates gives general mill concentrates averaging in the neighborhood of 9% copper, 16% insoluble and 30% iron.

The typical grading and assay of feed of the flotation machines and tails therefrom are shown in the accompanying table

GRADING AND ASSAY OF FLOTATION FEED AND TAILINGS

	Feed			Tailings		
Screen Size	Wt. % Solids	Assay % Cu	Wt. % Cu	Wt. % Solids	Assay % Cu	Wt % Cu
On 65-mesh	7.5	1.18	3.4	7.2	0.56	12.7
100-mesh	11.5	1.62	7.1	12.5	0.38	13.7
200-mesh	20.4	2.33	18.0	22.2	0.22	13.5
Through 200-mesh	60.6	3.08	71.5	58.1	0.39	60.1
Total	100.0	2.05	100.0	100.0	0.39	100.0

Now, since the subsequent handling, roasting and smelting of concentrates are expensive, it is our aim to make as high copper concentrates as possible, and for this purpose the selective action of the flotation machine is very valuable as showing a preference for copper over iron. On the other hand, the gold and silver values in our ores generally follow the iron rather than the copper, and hence we do not desire to lose the iron if in so doing an unduly high loss in precious metals is sustained, and, moreover, up to the present time we have always found that a better recovery is made by the flotation plant if the heavy iron sulphides are removed from the ore before it is treated in the flotation machine.

These factors necessitate careful calculation and the accumulation of a considerable amount of data on which to base such calculations, and just at present we are not prepared to state definitely whether it will pay to continue, as at present, to make roughing-table concentrates and then to follow this with the flotation machine, or whether ultimately we shall find it to our advantage to float our minerals first and afterward table the tailings for such coarse mineral particles as may be contained, as is at present the practice at Inspiration. The calculations are complicated by the metallurgical conditions at the smeltery, where, up to the present time, we have always had an excess of silica to offset which we have been obliged to purchase basic flux (either limestone or basic copper ore), and in the custom material that we have purchased, we pay four cents per unit for the iron and lime contained and charge the shipper for all silica contained. It is therefore obviously to our advantage to retain the iron in our concentrates, provided that by so doing we do not make too low-grade concentrates on which the smelting costs would offset the gain in fluxing value.

Crushing and Grinding the Ore

Crushing and grinding has presented several difficulties, owing to the nature of the ore, which is exceptionally hard and tough. In starting out to enlarge the capacity of the concentrator, we used a jaw-crusher to reduce the ore to about a 3-in. ring and followed this with a Symons disk crusher which was intended to deliver a product passing a 1½-in. ring, and the product to be delivered to a 6-ft. cylindrical ball mill and a 6-ft. Hardinge ball mill which were intended to reduce practically all the feed to pass 8-mesh, the same to be further reduced by Hardinge pebble mills in closed circuit.

The ball mills of both types proved entirely unequal to the task allotted to them, not through any fault of their own, but simply because we were demanding something that proved impossible, and even the impact of a 5-in. steel ball failed to crack the larger pieces of ore, many of which went through the mills and came out as round unbroken pebbles the size of marbles. To remedy this fault we put a 1-in. trommel after the Symons disk crusher and returned the oversize, thus running the Symons machine in closed circuit. This practice considerably increased the tonnage that the ball mills would handle, but resulted in unduly heavy wear on the Symons disk crusher, and eventually we decided to install rolls to handle the oversize from the trommel and at the same time reduce the screen of the trommel to ¾-in. as used at the present time. The feed to the ball mills will now all pass ¾-in., and on this basis the ball mills are doing very good work and are crushing twice as much feed per day as could be passed through them when the 1-in. screen was in use, and it is our intention to install heavier rolls later and to reduce the feed to the ball mills to pass ½ in., which will make a better arrangement.

The extreme hardness of our ore may be shown by another illustration, but in this second case we have been able to utilize this hardness to good advantage. The fine-grinding of the ore in 8-ft. Hardinge pebble mills was previously, for a short time, done with flint pebbles and the cost of the pebbles for grinding the very hard ore amounted to upward of 15c. per ton and would have been considerably more at the present higher price of pebbles. Gradually we substituted for the pebbles our own ore from the Blue Bell mine, using blocks of ore about 4 or 5 in. in diameter, and choosing this material from the stopes in which the ore was hardest and heaviest. For a long time past no pebbles at all have been used, but the lump ore is fed into the Hardinge mills through the discharge end and the average consumption is slightly less than 9 tons of this ore per day, or about one-fiftieth of the feed to the mill.

The ore blocks as fed into the mills cost about $2 per ton more than the crushed ore as delivered in the regular manner, but the mineral contained is, of course, added to the concentrates as these grind up and amply repay this extra charge, and therefore the net saving in using block ore instead of flint pebbles may be considered as 15c. per ton of ore concentrated.

Generally speaking, the commercial minerals in our ore float in an entirely satisfactory manner and when clean sulphide ore only is sent to the mills, an excellent recovery is obtained, sometimes as high as 95 or 96% of the values, including the recovery made by the roughing tables. Various mixtures of oil have been tried out during 1916; the average mixture used had the composition shown in the table

COMPOSITION OF FLOTATION OILS

67.7%	Standard Oil Co.'s Stove Oil 27 plus
25.7	Pensacola Tar and Turp. Co.'s No. 200
6.6%	other oils
100.0%	

and on the average 1.387 lb. of oil per ton of ore was employed, the cost representing just about three cents per ton of ore. At the present time we are using the mixture of oil shown in the accompanying table,

FLOTATION OILS NOW USED

70.4%	Standard Oil Co.'s Stove Oil 27 plus
24.9%	Pensacola Tar and Turp. Co.'s No. 200
4.7%	Standard Oil Co.'s Calol fuel oil 24 plus
100.0%	

and the amount is about 1.31 lb. per ton of ore and the cost about 2.5c. per ton.

Operating on the hard ore mentioned with a comparatively small tonnage and a mill that was in the first case poorly designed and that has been remodeled piecemeal, the working costs are naturally rather high; the best yearly record was made in 1915, when the total cost of milling was $1.06 per ton exclusive of flotation royalty. The costs in 1916 were increased by the higher prices of material and particularly by the higher cost of labor, and the cost in that year was $1.36 per ton, excluding flotation royalty. A division of the working costs for 1916 is, excluding flotation royalty: Crushing, $0.391; grinding, $0.471; tabling, $0.262; flotation, $0.240.

Improvements in Metallurgical Treatment

During recent years the improvements in concentration practice, and more particularly the advent of flotation, have worked a great change in the smelting conditions and practice. Flotation has not only made possible the profitable treatment of many ores that could not be successfully handled by gravity, but as an adjunct to gravity concentration has greatly improved the recovery of metal and the grade of concentrates produced, and to meet this situation the nature of smelting equipment has been radically altered, the blast furnace being more and more replaced by roasters and reverberatories. There are, of course, certain classes of ore that consist essentially of massive iron and copper sulphides, which naturally are treated in the blast furnace and for which no other means of treatment would be at all satisfactory; and conversely, such ores as are found in the porphyry coppers and in other mines with comparatively low-grade copper and high silica content can be treated only by concentration and subsequent smelting of the concentrates.

At Humboldt, however, much of our ore falls in what might be termed the "twilight zone" between concentration and direct smelting, and the decision as to whether certain portions of the ore produced should be concentrated or directly smelted in the blast furnace is a matter that can be decided only after careful calculation and the collection of a considerable amount of both milling and smelting data.

The smeltery at Humboldt is equipped with both blast-furnace and roasting and reverberatory plants, and very careful records as to the recovery and costs in both these departments must be utilized in deciding the best manner of treatment for portions of the orebodies that are neither very basic nor very siliceous. The very siliceous ore, coming largely from the De Soto mine and containing upward of 65% insoluble is, of course, a straight concentrating problem, and likewise the most basic ore at the Blue Bell, higher in gold and silver and containing in the neighborhood of 4% copper, 35% insoluble and over 20 units of iron and lime, constitutes an excellent blast-furnace charge. Between these two extremes the bulk of the production of the mine varies, and varying conditions, costs and recoveries in gold, silver and copper at the mill and smeltery determine just where the line between milling and smelting ore is to be drawn.

At present we find it to our advantage to concentrate all ore containing less than $2 in gold and silver and less than 3½% copper, where the insoluble exceeds 40%, which means that the iron will not exceed 16 or 17%. On the other hand, with the ore that is higher in gold, silver and copper than the foregoing and which (as usually follows) contains less insoluble and more iron, direct smelting is more profitable than concentrating.

As the development of our concentration proceeds and lower working costs are attained with better recoveries also, the balance should swing in favor of concentration, but on the other hand, as conditions and equipment at the smeltery are improved at the same time, factors in favor of direct smelting will be introduced, and the only way in which this question can be intelligently decided is by continually refiguring the calculations with the varying factors obtained from the latest cost and metallurgical records.

Enlarging a Pulley

Frequently it is necessary to increase the size of a wooden pulley by a fraction of an inch; up to ¼ in. may, in many cases, be successfully accomplished by applying layers of common newspaper, each layer being given a good heavy coat of shellac. Don't try to pull the wet paper tight—you can't do it. Lay it on smooth and trust the shellac to do the rest.

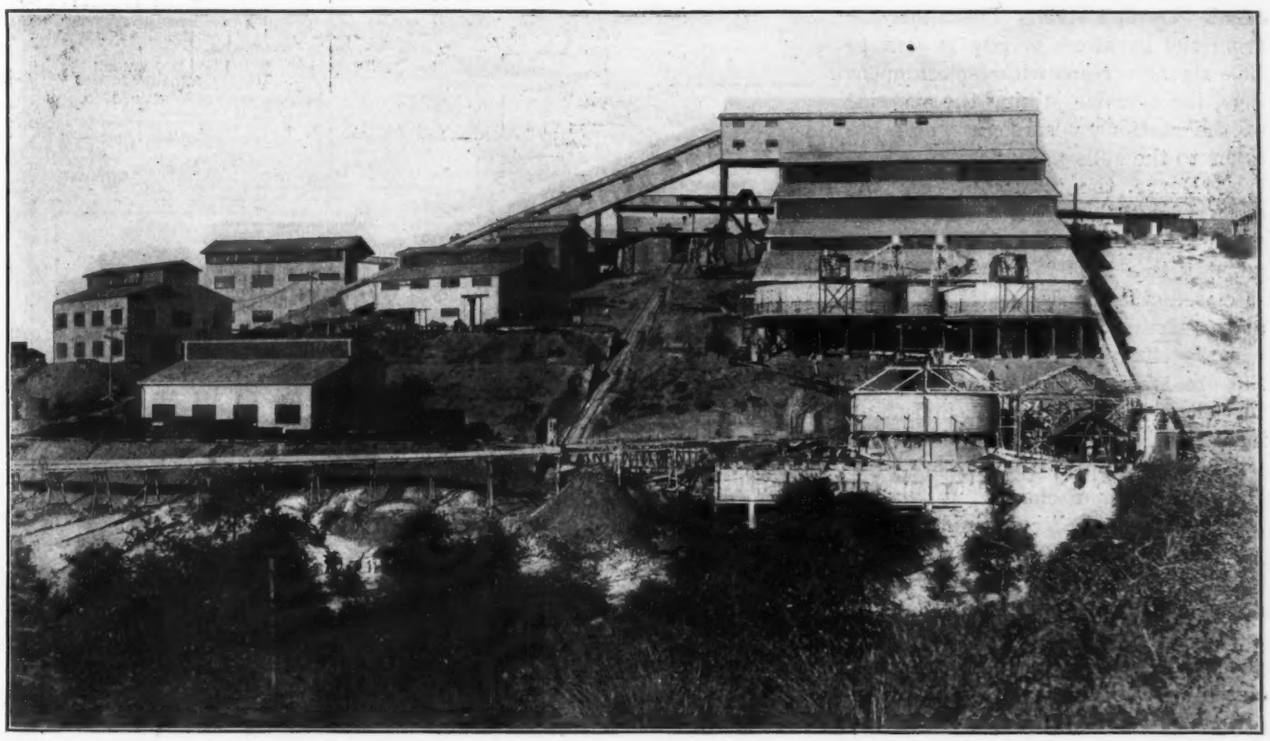
Cadmium Precipitation—In a recent issue of the "Chemist-Analyst" Andrew J. Whittstat suggests as a means of hastening the precipitation of cadmium as sulphide in spelter analysis that sulphureted hydrogen be passed into the solution from five to ten minutes, then make slightly ammoniacal with ammonium hydrate (thus precipitating both Cd and Zn) and acidify with dilute sulphuric acid, after which pass the gas in for about an hour to precipitate.

The Burro Mountain Concentrator

By F. C. BLICKENSDERFER
Metallurgist, Burro Mountain Branch, Phelps Dodge Corporation

The Burro Mountain concentrator of the Phelps Dodge Corporation was started in April, 1916. It includes many new forms of machinery and some new ideas in concentration. The new features include fine reduction of ore in a dry state, installation of Butchart tables, Marathon mills and Rork flotation machines, Senn concentrators and the use of individual motors on most of the machines.

THE concentrator of Phelps Dodge Corporation, Burro Mountain Branch, is at Tyrone, N. M., on the El Paso & Southwestern System, about 20 miles west of Santa Rita and Hurley, and 15 miles south of Silver City. The concentrator consists of two 700-ton units and was designed to treat the low-grade Chemung and Burro Mountain ores of this company, according to the results from test-mill experiments obtained during 1914 and 1915. One section of the plant was put into operation in April, 1916, and the second section in May of the same year.



THE BURRO MOUNTAIN MILL OF THE PHELPS DODGE CORPORATION, TYRONE, N. M.

The ore is hauled from the Burro Mountain mines by standard-gage trains in side-dump all-steel cars of 30 and 50 tons' capacity. The total distance of haulage is about three miles, one-half of which is comparatively level and the other half on a steep grade. A Fairbanks track scale is placed near the mill for the purpose of weighing out concentrates and weighing in ore for scale tests, thus providing for convenient weighing at the point where it is required.

The ore cars are pushed to a track that extends the full length of the coarse-ore bins. These bins are 300 ft. long, 16 ft. 4 in. wide and 15 ft. 9 in. from the center of rail to the bottom. They are of concrete and steel throughout. The cross-sectional area of the bins is that of a rectangle with a V-shaped bottom. The sides of the V-shaped portion slope 45° and are reinforced with 10-lb. steel rails extending to the upper surface.

The ore is discharged through 35 pockets fitted with iron jaw gates operated by a rack and pinion. These pockets are spaced 8 ft. 4 in. between centers and permit of nearly all the ore being drawn without the aid of shoveling.

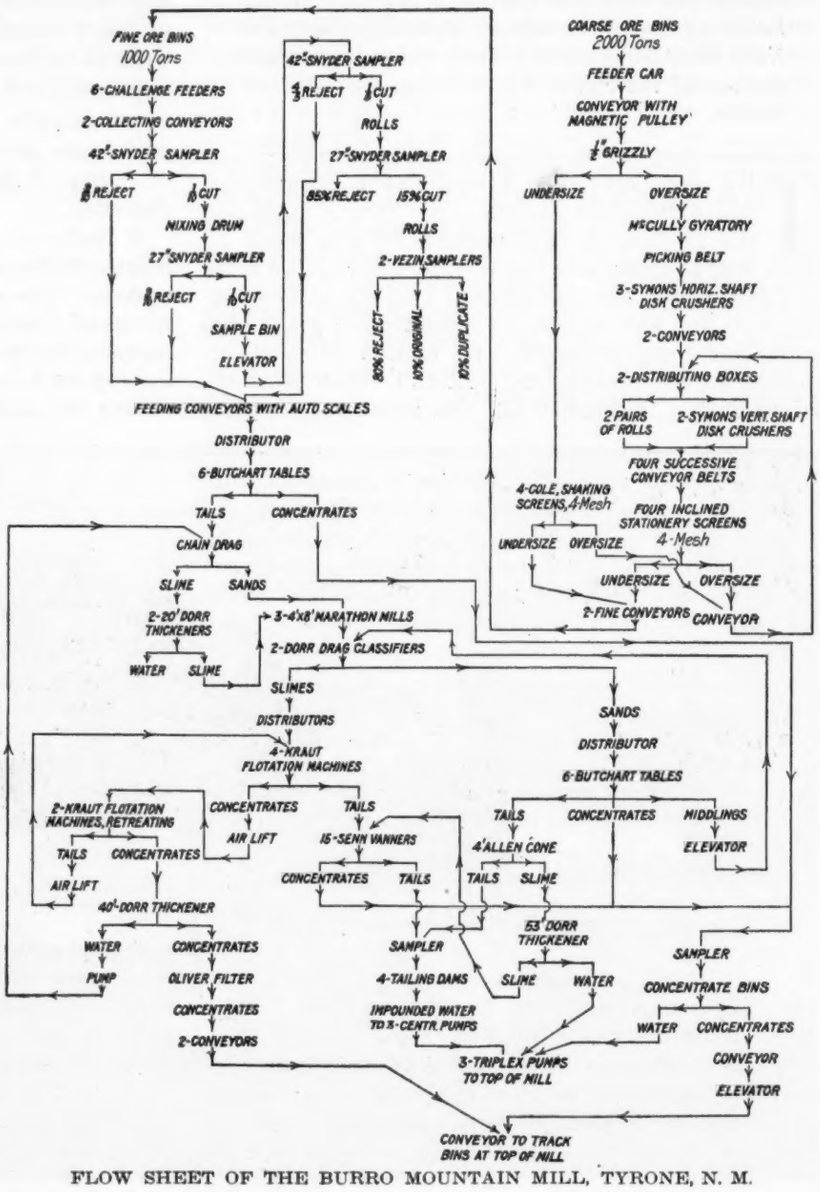
A feeder car that is capable of traveling the whole length of the coarse-ore bins serves any one of the 35 pockets. The car is driven backward or forward by means of a reversible gear wheel attached to the motor mounted on the feeder car. The car contains a slowly moving steel apron beneath the jaw gates to receive the falling ore, and the apron transfers it a distance of 8 ft. and discharges it upon a 30-in. conveyor belt, traveling 182 ft. per min. Before reaching the end of this belt, any wood that is visible in the ore is removed. The head pulley is magnetic to remove "tramp" steel.

The ore discharges upon a bar grizzly, spaced ½ in. in the clear, the undersize going to the fine screens and the oversize to a No. 8 Telsmith gyratory crusher set to deliver a 3½-in. maximum product.

The gyratory product goes to a 48-in. picking belt traveling 60 ft. per min., over which is hung a powerful magnet to remove any "tramp" steel that has escaped

the magnetic pulley. Pieces of wood are removed by hand, and any large, flat pieces of ore that have fallen through the gyratory are broken up with a small sledge.

The ore is then discharged to three 48-in. Symons disk crushers set to produce a maximum size of one inch. Two 18-in. conveyor belts, traveling 266 ft. per min., carry the 48-in. crusher product upward to a distributing box, whence it goes to two 54 x 24-in. Allis-Chalmers rolls and two 48-in. Symons fine-reduction disk crushers. The rolls and fine disk crushers are set to crush to a ¼-in. product. A 24-in. conveyor belt with a velocity of 258 ft. per min. collects the products from the two rolls and the two fine Symons machines and discharges to a series of three conveyor belts of similar size and velocity set at right angles, the final conveyor discharging upon stationary screens of 4-mesh opening. The screen oversize is received by an 18-in. conveyor traveling 277 ft. per min., which carries it back to be equally distributed between the two pairs of rolls and two fine disk crushers. There is a third and final magnet over this belt to insure complete removal of all "tramp" steel. The undersize from the gyratory grizzly is sent to Cole zigzag screens with 4-mesh openings, the oversize joining the oversize of the stationary screens, which returns to the rolls and fine disk crushers. Hence, the total mill feed has been reduced to pass a 4-mesh screen by dry-crushing alone, and in accomplishing this it is necessary to grind in closed circuit. The total undersize of the screens is collected by a 24-in. belt traveling 266 ft. per min., thence the ore is discharged to another 24-in. belt at 283 ft. per min., and at an inclination of about 20°, which belt leads to the top of the fine-ore bins. Here the ore is discharged upon a 24-in. distributing belt containing a tripper car which discharges the ore into the fine-ore bins. The tripper car is not of continuous reverse motion, but is capable of being moved forward or backward by means of a gear and clutch operated by one of the conveyor-belt pulleys. The fine-ore bins are 110 ft. long for both units, 25 ft. wide and 19 ft. deep; they are constructed of steel throughout and hold 2000 tons. The bins are partitioned off into four equal sections holding 500 tons each.



FLOW SHEET OF THE BURRO MOUNTAIN MILL, TYRONE, N. M.

Three Challenge disk feeders are on the bottom of each 500-ton section to deliver the ore at a uniform rate. The ore is received by two 18-in. conveyors per unit, which discharge into the same hopper at the center of the unit. The hopper receiving the ore at this point contains a 42-in. Snyder sampler.

The Snyder sampler at the sample mill consists of a concave disk with two radial slots diametrically oppositely placed, with the ore stream impinging on the concave side. As the slots pass through the ore stream, a portion (10%) is deflected. The sample cut out is mixed in a revolving drum and discharged upon a second Snyder sampler, where 10% is cut out, the reject going to join the reject of the first cutting operation. The sample at this stage is 1% of the original ore stream and is collected in steel sample bins, over a period of 8 hours, when it is passed through the sample mill. An elevator carries the sample to the top of the sample mill, where a Snyder sampler cuts out 20%. This portion is crushed to $^{3}/_{16}$ in., the product passing to another Snyder sampler, which cuts out 15%. This portion is crushed to ⅛ in., the product going to a 28-in. Duplex Vezin sampler, which cuts 10% and 10%, forming duplicate samples.

The reject from the different samplers are collected in a bin at the bottom of the elevator, and when the sample has been run through, the reject is elevated in the sample-mill elevator and discharged upon the feeder collecting belts. There is a man elevator from bottom to top of the sample mill, with steel-rod steps, spaced 6½c., and with a velocity of 70 ft. per minute.

The total ore stream is carried by conveyor over a Blake-Denison automatic recording and weighing machine, to a distributing box. These scales have been tested against the railroad track scales (tested by a test car), and they were found to be 0.47% low in the weighing of 21,000 tons of ore. The automatic scales are delicate instruments, but with careful adjustment have given splendid results.

The ore is of two distinct classes. The east orebody (also called No. 1 division) is composed of a quartz porphyry and quartz monzonite porphyry, with an average grade of copper of 1.90%, of which 0.20% is copper in the form of oxide and carbonate, and the remainder chalcocite. The Chemung (also called No. 3 division) is composed of granite, felsite and small amounts of quartz porphyry, with an average grade of 1.90% copper, of which 0.09% is in the form of oxide and carbonate, the remainder chalcocite. Both ores contain small amounts of water-soluble copper compounds, requiring the addition of lime for protection of iron parts.

SUPPLY HOUSE OF THE BURRO MOUNTAIN MILL, TYRONE, N. M.

The first step in concentration is effected by six Butchart tables per unit. These tables are fed from a distributing box composed of a revolving drum with a sloping bottom in which there is an opening at the apex in the periphery. The opening revolves uniformly over six equally partitioned segments of a circle, and as water is added in the revolving drum, an equal distribution of feed takes place. The percentage of solids in the table feed ranges from 35 to 40. Each table treats about 150 dry tons of feed per 24 hours, with an initial tonnage of 700 per unit, since one table is usually shut down for reriffling or repairs. The table concentrates are discharged directly to the main concentrate launderer, the tailings containing 30 to 35% solids, going to a chain drag.

Before the tailings from the roughing tables are subjected to finer grinding, the excess slime and water is removed in the overflow of the chain drag, the coarse sand at the same time being dragged clear. The overflow goes to two 20 x 8-ft. Dorr thickeners, whose overflow of clear water is used for wash water on lower levels, and whose thickened discharge partly combines with the drag sand to form the feed for three Marathon mills. The remainder of the Dorr-thickener underflow bypasses the Marathon mills and enters the Dorr drag classifiers. The Marathon mill used in this plant is 4 ft. in diameter and 8 ft. long. It is driven by a direct-connected 50-hp. motor, transmission taking place in two stages of common gear reduction. It has been found that with rigid shafts the gears are easily stripped, so that the motor shaft contains a flexible coupling, and the shaft carrying the second reduction is also fitted with a flexible coupling. One of the mills has been driven by a flexible chain from the motor shaft to the first shaft of the Marathon drive gear, and so far it has proved successful. Experiments covering a period of three months have established the following facts: The best speed is 28 r.p.m.; size of new rod best suited for this class of work, 1¼ in.; horsepower required for driving the loaded mill, connected as noted, 48; weight of charge of rods at initial filling of mill, 16,000 lb.; and height of rods in mill, 22 inches.

The tonnage of each mill on section A, treating an ore that is medium hard, is 300 tons per 24 hours, and the tonnage of each mill on section B, treating a much harder ore than A, is 225 tons per 24 hour. The quality of the product is +35-mesh 10%, and —200-mesh 33%. This product seems best adapted to a subsequent separation of sands for tabling and slimes for flotation treatment. The percentage of solids in the Marathon mill feed is about 60 (nearly 2: 1); pounds of rods consumed per ton of feed crushed, 1.70; pounds of liners consumed per ton of feed crushed, 0.17; and kilowatt-hours consumed per ton of feed crushed, 2.697.

These mills are operating satisfactorily, and it is intended to experiment further with them. A 20-ton crane serves the entire Marathon mill floor.

The fine-grinding product contains about 60% solids as it is discharged from the Marathon mills. The scheme of concentration requires a separation of sand and slime at this point, and two duplex Dorr drag classifiers have been selected to perform the operation. The drag classifiers are 18 ft. long by 5½ ft. wide, have a slope of

2½ in. to the foot, and the drive pulley revolves 100 r.p.m. Water is added to the Marathon-mill product as it enters the Dorr classifiers, while sprays and a water-box supply water at the head end of the machines to aid in washing the slime from sand. The sand removed by the classifiers contains about 5% of —200-mesh, while the slime overflowing the tail end contains about 15% on 100-mesh, and 20% solids (1:4). The percentage of solids at this point is carefully controlled on account of the flotation step following.

Fine-Sand Concentration

The Dorr classifier sands comprise about one-half of the Marathon-mill product, the drag slimes about one-half, or a separation into equal parts. The sand is delivered to a stationary distributor, from which six Butchart tables receive and treat the uniformly divided feed. These tables are of the same type as the roughing tables, except that their riffling is suited to the treatment of fine sands.

The proportion of solids of the table feed is 35 to 40%. Three products are formed—final sand tailings, middlings and finished concentrates, the middlings being elevated and returned to the Dorr classifiers, the concentrates entering the main concentrates launderer, while the tailings, containing about 20% solids, are sent to Allen cones for dewatering.

The Allen cone consists of a conical steel tank 4 ft. in diameter by 5 ft. deep. The discharge is regulated automatically. Feed is introduced to the cone through a vertical pipe extending below the plane of the top of the cone. Surrounding this feed pipe is a ring-shaped metal float, which is itself surrounded by a circular shield extending about 18 in. below the water level of the cone when full. The feed pipe and the shield act as guides for the float. The latter is connected by a system of levers to a hinged ball-valve on the bottom of the cone, and when the float moves, its motion is communicated to the valve. When the water and the feed enter the cone, the surface of the water is low and the float hangs to its lowest position, drawing the bottom valve shut. As the cone fills (in this case, with water and sand) the sand settles to the bottom and fills the tank, at the same time keeping water and slime floating above itself. When the sand has banked high enough to obstruct the entrance of feed between the bottom of the shield and the banked sand, the water level in the shield rises and forces the float up. This motion serves to open the valve and let some sand escape, when the normal condition is established.

When properly set, the cone is automatic in its action and requires but little attention.

The sand product contains 75% solids and 2% —200-mesh material. The cone overflow contains about 4% solids, most of which passes a 200-mesh. The cone is at once a good deslimer and dewaterer.

The overflow of the cones is pumped by a centrifugal pump to the lower Dorr thickeners and subsequently treated on Senn vanners. The cone sand is sampled automatically and then discharged to the tailings launder.

The overflow from the Dorr drag classifier goes directly to the flotation machines of the Rork type. Each Rork machine is driven by a 15-hp. motor, connected by a flexible chain drive at a reduction of 109 to 17.

Most of the oil is sprayed by steam jets into the Marathon mills, only a very small amount of light oil being added to the machines themselves. The Kraut & Kohlberg disk oil feeder is used to supply the oil. The oil storage is located in two 14,000-gal. horizontal tanks, beneath the roughing-table floor.

The flotation process has not been a pronounced success. It has been definitely determined that insufficient agitation is the primary cause of such difficulties. Recently the tailings from one Rork machine have been re-treated in another Rork machine, and very good results have been obtained. This has been applied only to section A ore (Division 3 of Burro Mountain mines). The B section ore (Chemung) is of a different character and requires about 8 lb. per ton of commercial H_2SO_4. Without acid the results obtained are poor.

The data shown in the table have been established by actual experiment.

FLOTATION DATA AT BURRO MOUNTAIN MILL

Tons dry feed treated by each primary cell	75
Percentage of solids in feed	20
Pounds oil per ton of feed treated by flotation	2.75
With an additional 8 lb. of acid for section B.	
Horsepower per ton of feed treated	0.20
Size of motor	15 hp.

Life of drum, about 6 weeks; if there are considerable amounts of sand in the feed, the drum will be cut out in 5 weeks or less.
Flotation process will not work in a neutral solution.
Section A ore is indifferent to acid, but section B ore demands it.

This type of flotation machine has the advantages of mechanical agitation, but at the same time it does not escape the drawback of a large amount of repairs and high power required.

Concentrates-Filtering Plant

The flotation concentrates go to a 40-ft. Dorr thickener, which reduces the percentage of solids from 6% to 35% with a clear-water overflow. A small amount of vanner concentrates is added to the flotation concentrates to give them porosity. The Dorr-thickener overflow is pumped back to the top of the mill and added as initial water to the roughing table feed in order that any light oils may be utilized again.

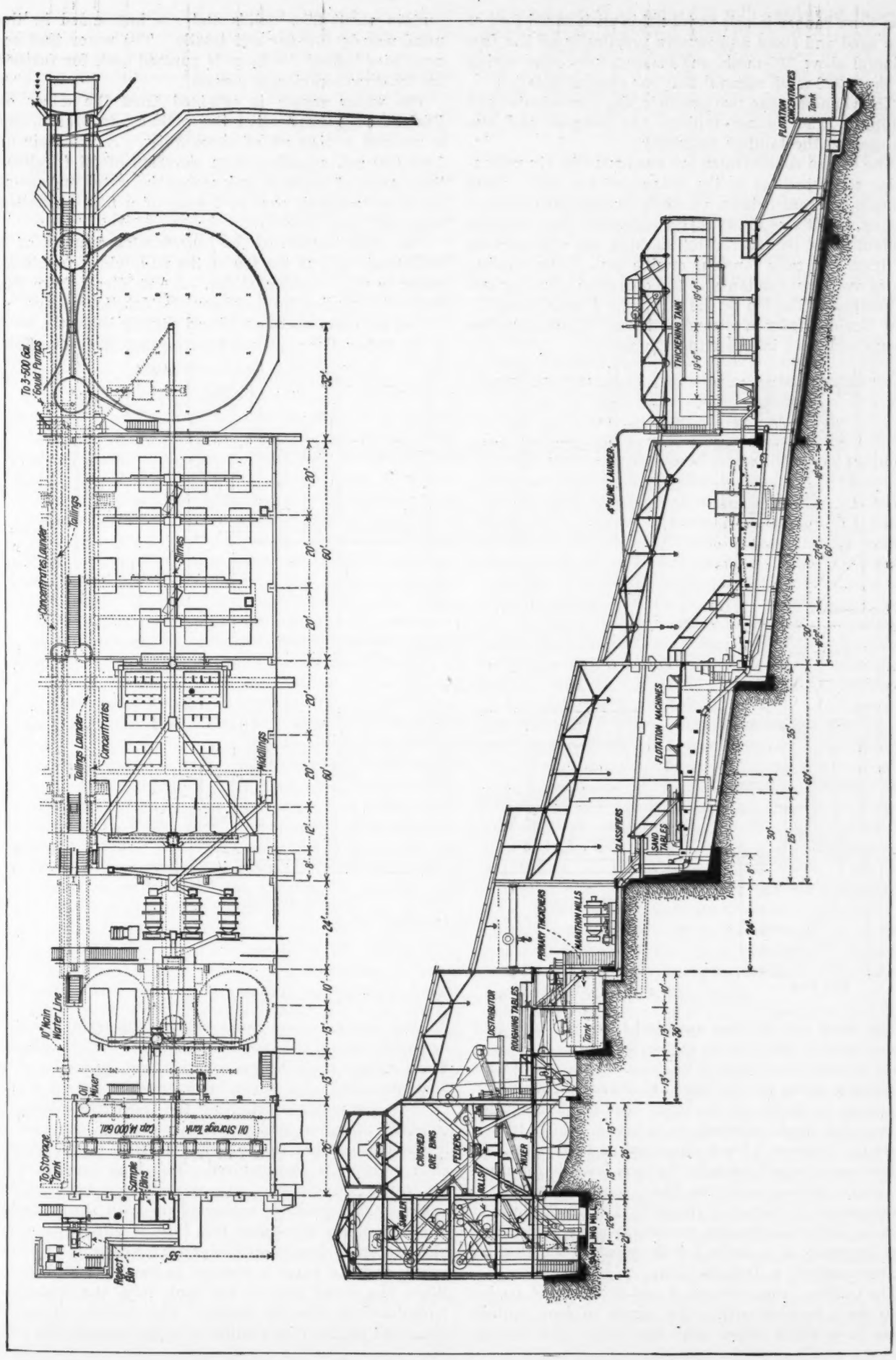
The thickener discharge is sent intermittently to a 14 x 14-ft. Oliver filter, which handles about 36 tons of flotation concentrates in 8 hours, with a range of solids in the cake of 20 to 30%, depending entirely on the amount of insolubles and alumina contained in the concentrates. The filter is operated only during the day shift.

A No. 3 Nash vacuum pump, operated by a 20-hp. motor, furnishes a vacuum of 21 in. on the drum of the filter. A filter canvas has a life of about six months.

The dried concentrates are collected on a small conveyor and elevated to another conveyor at right angles, thence discharged to the concentrates conveyor leading to the concentrates track bin at the top of the mill.

The tailings from the flotation machines are sampled and discharged to a distributor, which furnishes an even feed to 15 Senn pan-motion concentrators per unit. This type of vanner has both the side and end motion, the resultant action of which produces a natural circular pan motion. Each machine is 8 ft. long by 6 ft. wide, has a shaft speed of 150 r.p.m. and an adjustable cone speed for the belt travel. A 1-hp. motor is directly connected to each machine through ordinary gears with a reduction of 113 to 15.

The solids in the feed of the vanners are about 19%, and the dry tonnage per machine per 24 hours is 30.



GENERAL PLAN AND SECTION OF THE BURRO MOUNTAIN CONCENTRATOR AT TYRONE, N. M.

The Senn vanner is able to take this unclassified feed of fine sand and slime and remove practically all the free mineral above 200-mesh, and makes a very good saving of the —200-mesh mineral that has escaped flotation.

The vanners make two products, the concentrates and tailings. The vanner tailings are sampled and discharged to the tailings launderer.

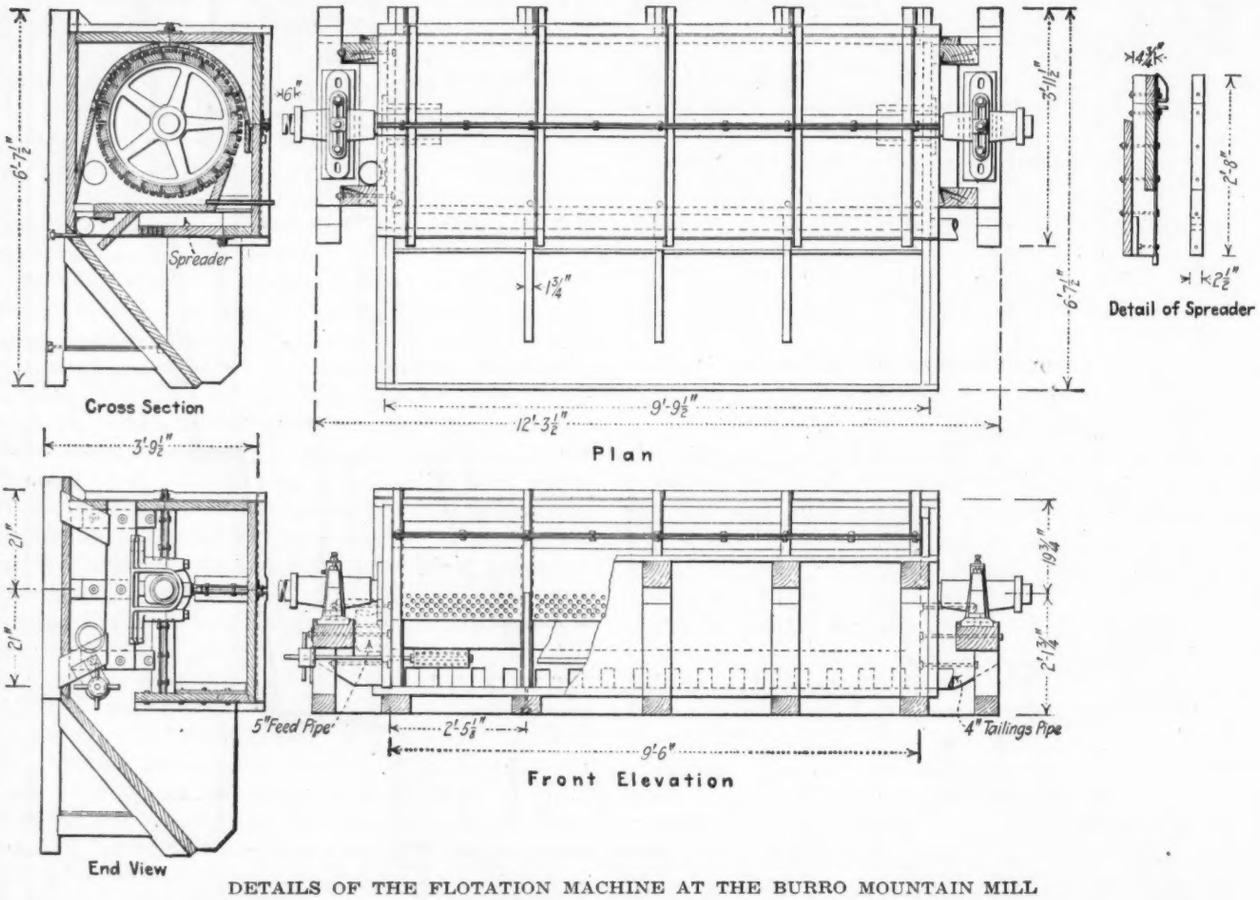
The coarse concentrates are conducted to six rectangular concrete bins at the bottom of the mill. They contain a porous bottom, formerly intended for vacuum drying, but it was found that a sufficiently low moisture content could be secured by allowing the concentrates to drain naturally for four or five days. The sluicing water overflows the tanks in the operation of filling and is pumped to the top of the mill from a small sump by two Gould triplex electrically driven direct-connected pumps and one 4-in. centrifugal pump.

contain about 25% solids and are impounded in the usual way by launder and trestle. The water that accumulates behind the dams is pumped back for further use by three centrifugal pumps.

The water supply is obtained from the mines of Phelps Dodge Corporation, Burro Mountain Branch, and is pumped a distance of three miles. A reservoir of 1,000,000 gal. capacity at an elevation of 25 ft. above the bottom of the mill tank stores the water and delivers it as required, part by means of a float-controlled valve and part directly.

The water system of the concentrator consists of a 16,500-gal. tank at the top of the mill, which furnishes water to the roughing tables. A line direct from the reservoir supplies the classifiers and flotation sprays.

Two auxiliary tanks are placed slightly below the level of the upper Dorr thickeners, receiving their overflow



DETAILS OF THE FLOTATION MACHINE AT THE BURRO MOUNTAIN MILL

The dried concentrates are discharged through four round holes in the bottom of the tank to a 24-in. conveyor running the length of the bins. While the process of filling is going on, the holes are closed by four plugs, extending to the top of the tank. The plugs are pulled by a chain block mounted on a crane, which travels above the tanks on a track supported on their walls.

The conveyor belt beneath the tank leads to an elevator which discharges to the 18-in. conveyor leading to the track bin at the top of the mill. The track bin is at such an elevation that the concentrates are loaded into cars by means of a chute, for shipment to the Douglas Branch smeltery at Douglas, Ariz.

The tailings from sections A and B unite and are led away in a launder with a 3% grade to four tailings dams in a small valley near the mill. The tailings

of clear water. These tanks supply wash water for the fine-sand tables and the head end of the classifiers. The auxiliary tanks keep a constant level by means of a float-controlled valve, supplying water from the top tank.

The clear water overflowing the concentrate bins is collected in sumps and pumped to a small tank on a level slightly below that of the two slime tanks, whose clear overflow is also received. This tank supplies water to the Senn vanners, the excess water flowing into another tank which is connected up with three Gould triplex pumps. Whenever this tank is filled with surplus water, a float-controlled switch starts the Gould pumps and the water is pumped to the upper mill tank. When the water level in the tank falls, the float-controlled switch stops the pumps. The quantity of water consumed per ton of ore milled is, on an average, 800 gal.

No attempt is made to economize on water by return pumping from the tailings dams, this being resorted to only when the supply of mine water runs low.

Drinking water is obtained from wells at the Fortuna pump station and is pumped to the concentrator, a distance of about three miles. A fresh-water tank and line, situated conveniently, furnish the mill with drinking and bath water.

Electric power is used exclusively and is obtained from the central power house of Phelps Dodge Corporation, Burro Mountain Branch, three miles away. The current is alternating and is received at 6600 volts in the transformer house through a choke-coil lightning arrester, an oil switch, then through three single-phase 300-kv.-a. transformers. The voltage is reduced to 440 and 220, the former for power and the latter for lighting.

Assaying and Sampling

The sampling has been made as nearly automatic as possible. The Flood automatic sampler, with modifications, is the type installed. The vertical shaft of the original machine has been lengthened to protect the bearing from splash, and the cutters have been constructed of sheet copper with radial slots, instead of the parallel-sided slots as furnished by the manufacturers.

Each unit is equipped with the samplers set at the following points: Roughing table, concentrates and tailings; sand table, heads, tailings and concentrates; flotation, heads, tailings and concentrates; vanner, heads (which is flotation tails), tailings and concentrates; unit tailings and concentrates and a general tailings sampler, which, by the way, is the old familiar type of tilting water box. By this arrangement each group of machines is sampled daily and an accurate check of each separate step in the process of concentration is maintained.

All samples are transferred to a bucking room, on the roughing-table floor, which is fitted with a steam dryer, two Braun planetary disk pulverizers, one vertical disk grinder and a "coffee mill." Composites of the more important samples are made over 10-day periods and screen analyses made by a Tyler Ro-Tap testing sieve shaker. As an index to the accuracy of weights and assays, the saving of the concentrator since Jan. 1, 1917, figured on a basis of copper in ore and concentrates only, checks the saving of "assays only" within 0.2%.

The assay office is modern and up-to-date in every detail. The furnace room contains an electric still with a capacity of 3 gal. of distilled water per hour. In the center of the room is a Case gasoline-fired assay furnace, containing a 15 x 9 x 4½-in. muffle. This is employed in all gold and silver assays. The balance room contains 7 balances: 1 Thomson button balance, 1 Ainsworth analytical balance and 5 Thomson analytical balances.

The laboratory room is equipped with an electric muffle furnace 5 x 4 x 12 in., and is adjustable through a range of seven different temperatures. All daily fusions are made in this furnace. The same room is fitted with a hood containing three electric hot plates 18 x 24 in., with three heats, low, medium and high.

The electrolytic stand for the precipitation of copper assays contains twelve 4-volt vertical motors. Hot water is supplied this room by two 10-gal. electric water heaters.

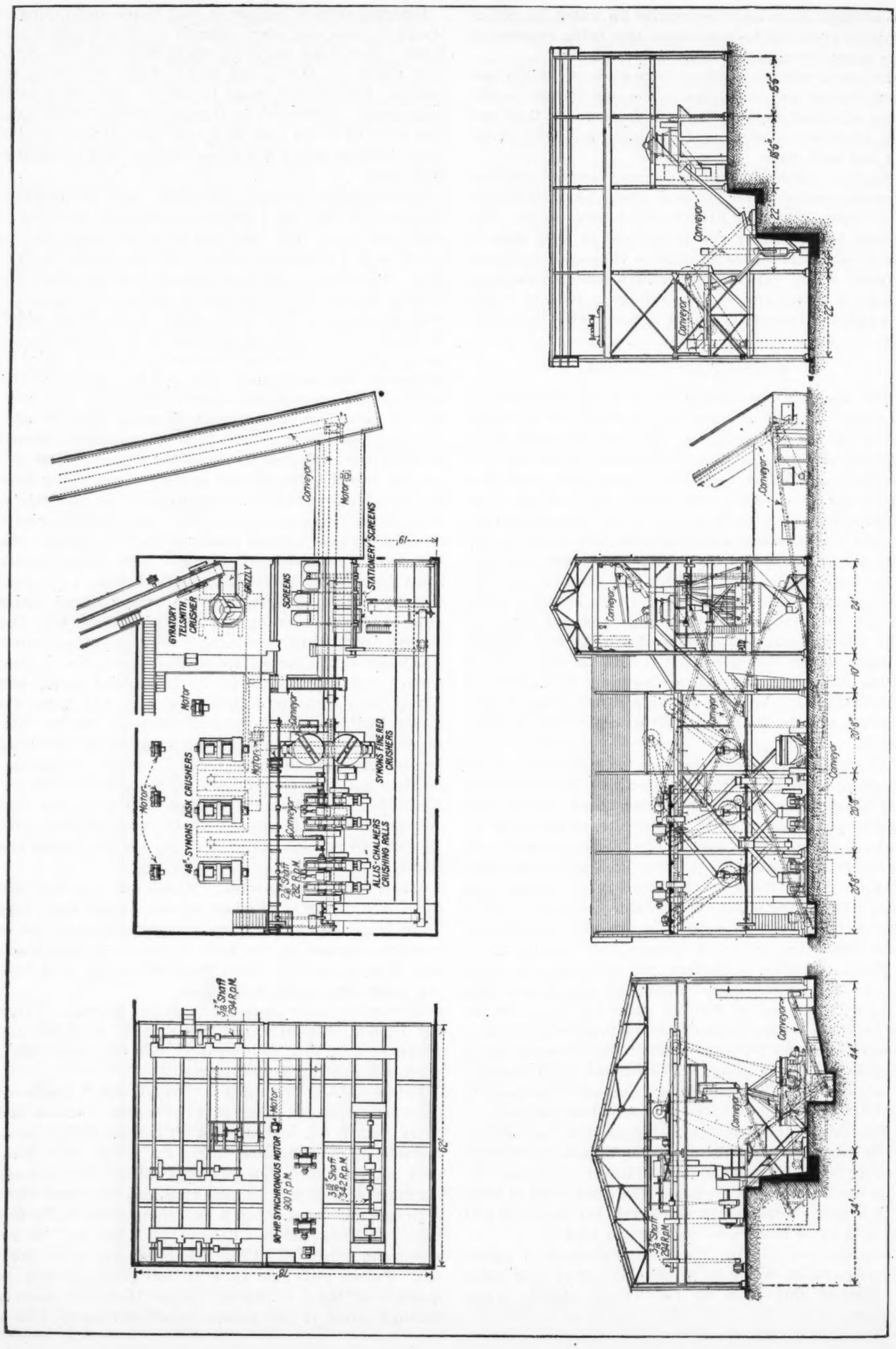
Determination of copper in mill heads and tailings: Weigh 1 gram ore, treat with 10 c.c. HNO_3 and 3 c.c. H_2SO_4. Run down the dense white fumes on hot plate, cool, add 5 c.c. HNO_3, add 25 c.c. water and bring to boiling. Fill up with water to 125 c.c. and cool in running water. Electrolize in Herman rotating anode cabinet with 1.8 to 2.4 amp. at 4 volts until H_2S on 2 minutes' standing with 2 to 3 drops solution fails to produce dark color.

Permanganate method for daily mill concentrates samples: Weigh out 5 grams concentrates, add 10 c.c. HNO_3 and 5 c.c. HCl. As soon as fumes cease, add 10 c.c. of a 4: 6 solution of H_2SO_4 and run nearly to dryness. Add 40 c.c. water and bring to boiling. Make the boiling solution slightly amoniacal and exactly neutralize with concentrated HCl, when exactly 3 c.c. HCl is added in excess. The solution is now placed on a hot plate, and 10 c.c. of a 10% solution of sodium sulphite is added to reduce all iron and copper, indicated by a paling of the solution. To the reduced solution 10 c.c. of a 10% solution of potassium sulphocyanate is added and the solution just brought to a boil. The precipitate is allowed to settle and is filtered, the tip of the breaker being previously coated with vaseline and the paper being kept but half full, owing to the creepiness of the precipitate. Wash three times with moderately warm water, twice ¾ of the filter-paper height and once the entire paper, the stems of the funnels being washed. The original beaker sides are now washed with a nearly boiling 7½% solution of sodium hydrate, and the beaker placed under the funnel. The precipitate is washed once with the sodium hydrate and then three times with boiling water. The sides of the beaker are washed down with boiling water. Add 30 c.c. of (1: 2) H_2SO_4 and water and titrate with standard $KMnO_4$, 1 c.c. = 0.01 gram Fe. Low's modified table is used to calculate results. Potassium permanganate is standardized by both iron wire and ferrous ammonium sulphate; 1.4 grams ferrous ammonium sulphate is weighed out, dissolved in 100 c.c. 1: 5 H_2SO_4 and titrated; 0.2 gram iron wire, rust free and polished, weighed into an Erlenmeyer flask with Bunsen valve dissolved in 100 c.c. 1: 5 H_2SO_4, cooled and titrated.

Insoluble in concentrates: Weigh out 5 grams, add 5 c.c. HNO_3, take to absolute dryness at low heat; take up in 10 c.c. HCl and 1 gram potassium chlorate, run to complete dryness in low heat, finishing on high heat; cool, take up in HCl; filter, wash thoroughly with boiling water, dry, ignite and weigh.

Method for oxide copper in heads and tailings: Weigh out 1 gram of sample, add 25 c.c., 10% of H_2SO_4 (by weight), bring to a boiling point. Boil for 2 min., filter, wash and electrolyze at 1 ampere.

Iodide method for copper: Weigh out 5 grams of concentrate sample, place in 7-oz. beaker, moisten and cover; add 5 c.c. concentrated HCl, then several cubic centimeters pure bromine, then 5 c.c. HNO_3. Run down on a hot plate for a few moments, taking care to avoid running to dryness. Remove from hot plate and allow it to cool a moment. Add 5 c.c. concentrated H_2SO_4 and bake to strong fumes. Remove, cool and add 30 c.c. water and a drop of HCl to precipitate any silver present. Put on plate and allow to boil gently 10 min. to dissolve all basic sulphates. Filter into 8-oz. beakers through quick 11 cm. papers, wash thoroughly 5 or 6



CRUSHING ARRANGEMENT AT THE BURRO MOUNTAIN CONCENTRATOR, TYRONE, N. M.

times with very hot water. To filtrate, add 15 c.c. hypo solution (commercial grade, filtered). Make up with water to about 150 c.c., cover and place on hot plate and boil until precipitated sulphides have turned dark and solution is clear and colorless. Filter through quick, 11-cm. papers and wash 5 times with hot water. A few cubic centimeters of Na_2S solution are added to filtrate to make sure of total precipitation of copper or test for any AS, Sb or Bi present. The filter with the copper sulphide is placed in a porcelain crucible and ignited at a low red heat. To the beakers from which the copper sulphides were filtered, add 5 c.c. of chlorate mixture ($KClO_3$ dissolved in HNO_3) and wash out of porcelain crucibles into corresponding beakers the ignited sulphides. Run down to dryness over gentle heat and bake off all smell of acids or chlorine. Up to this point the electrolytic method is exactly the same in procedure as the iodide method. Continuing with iodide method, cool and add a few drops of HNO_3 from dropper, sufficient to dissolve Cu. Wash down sides of beaker with fine stream of hot water and add enough more water to make up to about 40 c.c. Add NH_4OH until solution is clear blue. Boil to expel excess ammonia and until dark precipitate of oxide of copper has formed, then add 5 c.c. strong acetic acid and boil a few minutes. Remove and wash off cover and sides of beaker and cool. Assays are then ready for titration. A standard solution of sodium thiosulphate of 20 to 30 grams per liter is used, which will read direct percentages of copper on ½ gram and give a factor very close to 1. The solution is standardized with pure copper foil daily. Starch solution is made up frequently from soluble starch powder. The KI solution has a strength of 1 lb. to 2 liters and on an average 8 c.c. will be required per assay, the equivalent of 1.8 grams of the salt. All solutions are made in quantity proportionate to their use.

Continuing now with the electrolytic method at the last point of similarity to the iodide method: Add 1 c.c. nitric acid, 4 c.c. H_2SO_4 and 15 c.c. of ammonium-nitrate solution (3 kg. to 10 liters of water), dilute to 125 c.c., boil and electrolyze with $^6/_{10}$ amp. for about 30 minutes.

The concentrates shipped to the smeltery are assayed by the iodide method and checked by the electrolytic method.

General Local Conditions

The concentrator is built on a slope that furnishes plenty of fall for gravity concentration. All structures are built of concrete and steel, and the floors and retaining walls of the concentrator are of concrete of appropriate consistency.

There is a carpenter shop, a machine shop and a supply house. All necessary woodwork and machine work is taken care of and a complete stock of mill supplies is kept on hand. An incline hoist extends from the bottom of the concentrator to the track switch at the top. Branch switches extend to the platform of the incline-hoist car from the Senn-vanner floor, sand-table and flotation floor, and the Marathon mill floor on one side and the carpenter shop, machine shop and supply house on the other. The machine-shop switch extends into the crushing plant. A 15-ton hand derrick at the top of the incline serves the hoist from the track switch, thus providing a safeguard on estimations that prevents the occurrence of errors.

The results, summarized since operation, are shown.

RESULTS OF BURRO MOUNTAIN MILL OPERATION

Copper in feed	1.90%
Oxide copper in feed	0.15
Ration of concentration	10 : 1
Extraction total	72%
Sulphides	77%
Fresh water per ton	800 gal.
Power consumed per ton	9.0 kw-hr.

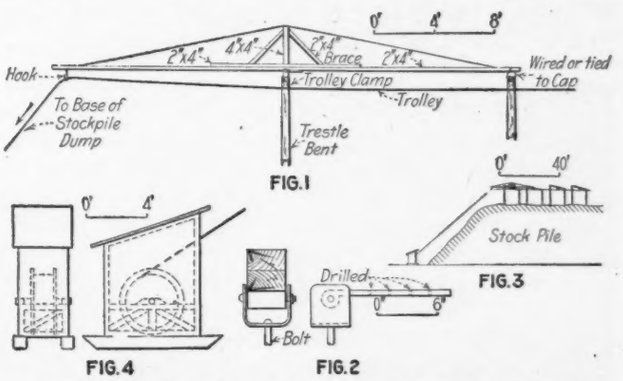
In view of the fact that the flow sheet has been constructed with entirely new types of machinery, this concentrator may be considered a new departure.

Extension Support for Stockpile Trolley

By D. E. Charlton*

Where motors are used in stockpile operations, several methods are in use for extending the trolley beyond the end of the dump. The accompanying sketches show one which is being made use of on the Missabe Range.

It consists of a beam (Fig. 1) fastened to a strap hinge and placed in a U-piece. The U-piece is bolted to the crosspiece of the last bent. (Fig. 2 shows hinge and U-piece in detail.) The beam is 2 x 4 in. and 31 ft. long and is reinforced at the middle by another 2 x 4 in., 10 ft. long. At the center is a 4 x 4-in. upright, 2½ ft. long and braced; ⅜-in. square iron braces extend from the top of the upright to within about 1½



TROLLEY EXTENSION SUPPORT FOR STOCKPILE

ft. of either end of the beam. The beam being placed in position, one end is tied or wired to the cap or crosspiece of the bent next to the last one, and the other swings out over the dump. A hook is placed on the far end so that the trolley is carried from the last clamp through the hook and from there to the base of the dump, where the remainder of the wire is kept on the original reel (Fig. 3). Fig. 4 shows the arrangement of a shed which is placed at the base of the stockpile and contains the reel. The framework is covered with 1-in. boards and the whole mounted on skids. Doors may be provided at the front and back ends, although these are not necessary. The reel is mounted on a 3-in. pipe which is supported on the framework provided. An iron rod, placed through holes in the reel and resting on the framework, serves as a stop to prevent the reel from unwinding. As the stockpile is extended, the shed may be moved out and the reel unwound as needed, thus doing away with any splicing of the trolley. Also, with the continuance of the dump, new bents will be placed on top and the beam-support will be moved to the last bent each time.

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Milling Wisconsin Lead-Zinc Ores*

BY WALTER SCHULTZ
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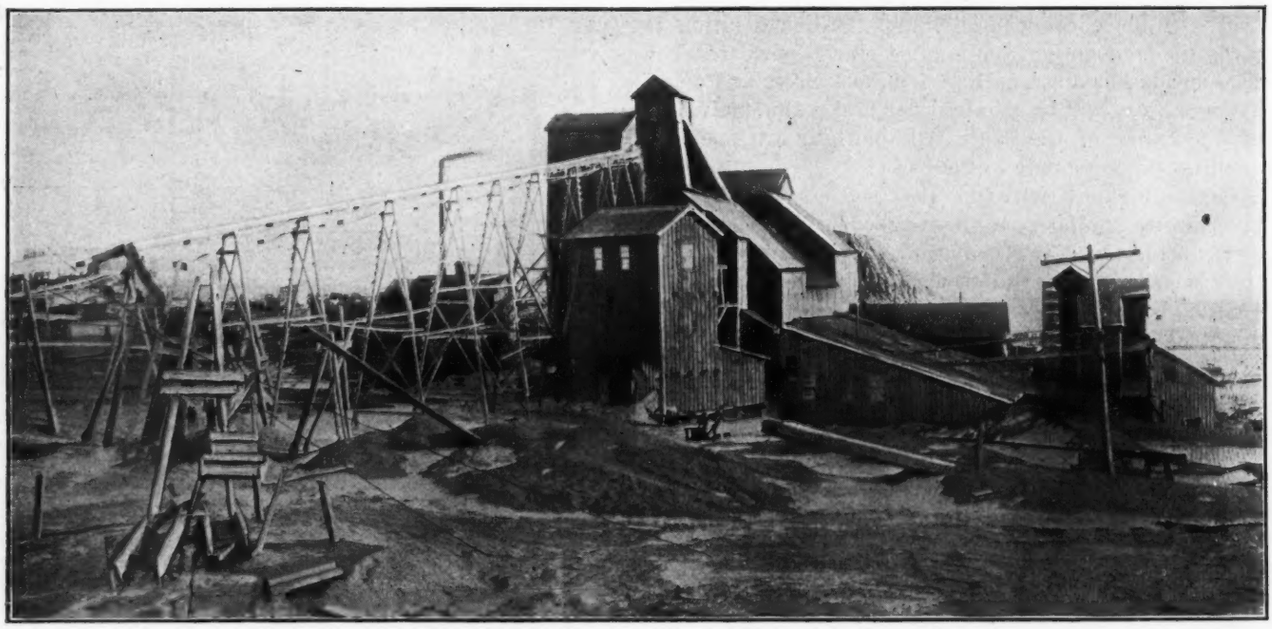
The Wisconsin ores are complex and contain sphalerite, marcasite and galena closely associated. Separation is principally by gravity methods, utilizing jigs. The equipment of a typical mill is outlined.

MOST of the ores milled in the southwestern Wisconsin district are of somewhat complex nature, for sphalerite, marcasite and galena occur intermingled and more or less closely associated. When the ore occurs in sheets it is free milling, but when it occurs disseminated in the country rock it is refractory. The country rock is dolomitic limestone, and as hoisted, the mill dirt assays up to 15% metallic zinc. An average value of heads in one of the large producers of the district is about 5% zinc. The average assay value of concentrates shows the wide range from 15 to 60% zinc.

The ore as hoisted in most of the properties is sent to a grizzly where it is hand-sorted and the large pieces of gangue, containing little zinc, are culled out and sent to waste. The amount of this gangue removed varies greatly, depending on the nature of the ore mined. A rough average is from 10 to 25% of the total hoisted. Since labor now is scarce and high-priced, some of the newer mills are treating all the dirt hoisted.

The separation of the concentrates is based upon the relative specific gravities of the minerals, and machines utilizing the principle of hindered settling are used almost exclusively. The majority of the mills use either one, two or three jigs, and some mills use concentrating tables in combination with the jigs. The capacity of a mill is based upon the tonnage of dirt the rougher jig will handle. As a rule these jigs have a capacity varying from two to three tons of feed per square foot of screen area per 10-hour shift. All the other machinery is proportioned accordingly.

The dirt from the hopper passes to the shaker screen, where all the fines made in the mine are screened out and sent direct to the dirt elevator, thus reducing the cost of preparing the dirt for the jigs and eliminating a large amount of fines. This elimination tends to lower the amount of zinc lost in the tailings. The oversize product from the screen is fed to the crusher, where it receives a preliminary crushing. It then goes to the first rolls, where it receives further crushing. The crusher and rolls are spaced so as to crush in balanced stages, thus reducing the fines and preventing the rolls from being choked by oversize material. The dirt is then elevated and passed through a trommel for sizing. The size of openings used in this trommel is based entirely upon the nature of the ore being treated. With free-milling ore much larger openings should be used than with a complex or refractory ore. It is good practice to make the openings as large as the ore will permit. In this manner the circulating load and slimes in the mill are reduced. The undersize product from this trommel is fed to the rougher jig, while the oversize is reground by the second rolls, after which it is elevated and returned to the trommel. The concentrates from the rougher jig pass through the cleaner jig for further concentration, while the tailings pass to the tailings pile and the chats are reground and either returned to the head end of the jig or fed to a sand jig. The concentrates from the cleaner jig, and sand jig where used, compose the final product of the mill, while the tailings from both are returned to the rougher jig.



THE CHAMPION MILL AT BENTON, IN THE WISCONSIN ZINC-LEAD DISTRICT

*Adapted from an article published in "The Miner," of the Wisconsin School of Mines.

The general jigging practice consists of a roughing and cleaning system. The first jig makes a rough separation, and its concentrates pass to a cleaner jig for re-treatment.

Rougher jigs are of the Harz type and have from six to nine cells, eight being the average number, with a plunger and sieve compartment for each cell. In general practice these compartments are built equal in size. As the plunger is given a clearance of ¼ in. on all sides, there is a loss of hydraulic pressure due to the leakage around it, and as the areas of the sieve and plunger compartments are equal, the hydraulic head delivered to the sieve compartment is reduced by this leakage. To overcome this loss of head, the area of the plunger compartment should be greater than that of the sieve compartment, which condition would permit the use of a shorter stroke, a smaller hydraulic head and a larger throat in the jig, all of which tend to produce a freer action of the beds and a reduction in power consumption.

Care should also be taken that the plungers do not run in synchronism, but rather at 90° apart, for all these conditions tend to produce a freer action of the beds, less wear and tear of the jigs and a reduction in power consumption.

Combined Rougher and Cleaner Jig

In one mill the jig is used both as a rougher and a cleaner jig. When used this way, the jig is usually given deeper beds, more back water, shorter stroke and finer-meshed sieves and is run at a higher speed than where used only as a rougher jig.

As cells Nos. 1 and 2 receive a heavy load of galena and marcasite, as well as a large overburden, these cells are not given the long stroke. In order to balance this condition and have free action of the beds, a large amount of back water must be used. As the specific gravity of galena is much greater than that of any of the other products being treated, and since this mineral has a cubical structure, it presents a small face for the water to work upon and therefore settles rapidly and forms lead-cleaning cells from which the lead concentrates are drawn. The float and chatty lead along with a large amount of marcasite not caught in cell No. 1, are caught from the hutch of cell No. 2 and returned to either the rougher or cleaner jig for re-treatment. As this product is lighter than the feed to cell No. 1, it requires a longer stroke with less back water than cell No. 1. The sieves used on these cells usually have ⅛-in. openings.

The practice of treating lead varies with the amount of lead found in the feed. If the feed contains a large amount of lead, three cells are used on both the rougher and cleaner jigs instead of two cells as is the case with a small amount of lead in the feed. The practice of returning the hutch products from these cells varies, it being either returned to the cleaner or rougher jigs. The best practice is to return the product to the rougher jig, for by so doing the lead is kept away from the mill concentrates made by the cleaner jig, resulting in a lowering of the lead assay of concentrates.

Cells Nos. 3, 4, 5 and 6 are used for the concentration of the sphalerite and marcasite. In the case of a one-jig mill these hutch products should not contain more than 2% lime, whereas in the case of a two- or three-jig mill these cells are used in the true sense of a rougher and carry lime to the extent of 4 to 6%. The jig when operating as a rougher has longer strokes, less back water, coarser sieves and shallower beds than when it is used as a one-jig mill.

Cell No. 3, which receives the richest feed of sphalerite and marcasite, produces not only hutch concentrates, but also bed concentrates which are drawn off as required to keep the bed at its proper depth. In order to obtain clean bed concentrates from this cell, a deep bed is desirable. As marcasite has a specific gravity greater than sphalerite, it is important that it be drawn from the jig as soon as possible, for if a heavy bed of marcasite be allowed to accumulate upon the jig, the sphalerite will have a tendency to pass to the lower cells. The reason for this is that the marcasite closes the holes in the sieves, preventing the sphalerite from being drawn down to form a hutch product. This results in a low efficiency of the jig and a high zinc content in the tails.

Cells Nos. 4 and 5 generally carry shallower beds with a long, slow, pulsating stroke and less back water than the preceding cells.

The depth of the beds should vary inversely as the richness of the feed and should at all times be as shallow as possible to give the maximum efficiency. The bed, in order to be a good filtering bed, should grade from fine to coarse sphalerites, followed by the heavier to lighter gangue materials.

The amount of top water increases at the lower end of the jig on cells Nos. 7 and 8, and the products to be recovered are lighter and, being in the form of chats and fine sphalerite, present a comparatively large face to be acted upon by the water, thus producing a tendency toward carrying them into the tailings. To overcome this condition, shallow beds, a long, slow, pulsating stroke and a small amount of back water should be used. As these beds are heavily drawn, sieves with smaller openings should be used to prevent an excess amount of fine free lime from being returned.

The pitch of the sieves used on a rougher jig is based entirely upon the amount of pitch given to the riffle. If it is found that the marcasite at the head of the sieve becomes smooth and rounded, permitting large amounts of lime to be deposited in the hutch and causing live and dead spots in the bed, it may be concluded that the pitch of the sieve is too great to allow the carrying of the bed forward over this grate. Live and dead spots will also occur if the beds are not properly spudded and kept clean. Care should be taken when placing a new sieve in a cell that the perforations are placed with the small opening up, for placed in this manner, they have a greater tendency to keep clean automatically.

The Use of Chat Draws

There are three main types of chat draws used, as follows:

Gate and dam draw. This has a tendency to draw the beds too heavily at the point of discharge, thus causing live and dead spots in the bed.

The Missouri hole draw. This has two failings. The first is that it has a lack of water control. The second is that it causes a very noticeable live spot over the entire end of the cell.

The Center or Baldwin draw. This has far greater efficiency than the formerly mentioned types, for it has water control and also tends to draw the beds uniformly, thus avoiding live spots.

The portion of the sieve adjacent to the draw has a tendency to carry a shallower bed than the remainder of the sieve, thus causing this portion to draw more rough products than the remainder. This condition causes this portion of the sieve to have its openings worn much faster than the rest, and also produces a live spot that is liable to pull down an excess of lime.

If, in the operation of the jig, it is found that above certain beds larger amounts of fine, free zinc than coarse lime are present, it may be corrected by reducing the amount of back water.

Oversize products in beds, due to poor screening conditions, destroy a bed for the following reasons: They replace the filtering sized product, thus causing the bed to become loose, which results in a large amount of lime in the hutch and a loss of fine sphalerite in the tailings. Therefore these oversized products should be removed as soon as possible.

In order that the jig may produce to its maximum capacity, it must have even, constant power and load; proper speed and stroke; proper depth of beds, riffles and sieves; a minimum amount of top water, and the sphalerite and marcasite should be properly drawn from the beds on the head sphalerite cells, but enough should be allowed to pass to the lower cells to keep their beds new and in good condition.

Adjustment of the Cleaner Jig

As the cleaner jig is used entirely to produce finished concentrates, it is of importance to keep the adjustments very accurate, for this jig must make a high recovery of sphalerite and a clean separation from the lime. As in the operation of the rougher jig, the lead cells receive a fairly high speed, small-meshed sieves, deep beds and a large quantity of back water. Since the cleaner is used principally to separate the sphalerite from the lime and since its feed contains a greater amount of sphalerite than of gangue, a larger amount of back water and shorter strokes are necessary. Great care should be taken that no dead spots occur under the sieves, due to the presence of foreign materials, such as chips, leaves and waste. Also that the sieve rests do not protrude too far under the sieve, which would likewise produce dead spots. Live spots in the bed may be overcome by the use of baffle boards placed in the beds immediately below the spot, which will build up the bed. The water fed to the plunger compartment should be free from slimy material. If an excessive amount of fine lime be found in a cell, the back water should be increased, but if the lime is coarse and the sieve in good condition, the stroke should be reduced.

If the back-water adjustments fail to reduce the lime in the hutch, the following very simple and accurate method, originated by the author, may be used to determine whether the cell requires a greater or a smaller stroke:

The specific gravity of the bed is increased by the addition of a few shovels of marcasite. If this causes a reduction of the lime in the hutch, a shorter stroke is required, and vice versa.

It is good practice to increase the depth of the beds gradually toward the tail end of the jig, as the bed has a tendency to grow lighter, due to the presence of a greater percentage of chatty material and a consequent reduction in its specific gravity.

The feed to sand or chat jigs is composed of reground chats. They must have deep beds, a high speed and a large amount of back water. The accompanying table gives a complete list of mill equipment required for a standard plant:

EQUIPMENT OF A STANDARD ZINC MILL

1. Grizzly, spaced 8 in.
2. Hopper, 300-ton capacity.
3. Crusher, 20 x 8 in., Blake type, 400 r.p.m.
4. First rolls, 36 x 18 in., spaced, 40 r.p.m.
5. Dirt elevation, 25 ft. high, 60 ft., 20-in., 6-ply belt, staggered cups 9 x 6 in. spaced 9 in., speed 400 ft. per min.; upper pulley 26 in. diameter 60 r.p.m., gear drive; lower pulley 24 in. diameter.
6. Trommel, 48 x 96 in., mesh ½ in., 7/16 in., round punched plate, 10 gage, 15 r.p.m., slope ½ in. per ft., bevel-gear drive.
7. Return rolls, 24 x 18 in., 40 r.p.m.
8. Smittem elevation, 25 ft. high, 60 ft. 20-in. 6-ply belt, speed, 400 ft. per minute; upper pulley, 26 in. diameter, 60 r.p.m.; gear drive; lower pulley, 24 in. diameter; cups same as dirt elevation.
9. Trommel, 36 x 72 in., 15 r.p.m., slope 1½ in. per ft., ¼ in. round punched 12-gage plate.
10. Smittem rolls, 12 in. Cornish, 8-in. face, 60 r.p.m., direct.
11. Chat elevation, 22 ft. high, 50 ft. 18-in. 6-ply belt; cups 9 in., 5 in., 5 in., staggered; gear drive; top pulley, 26 in., 55 r.p.m.; lower pulley, 24 in. diameter.
12. Chat trommel, 36 x 72 in., mesh 7/16 in. round-punched, 12-gage plate, slope 1½ in. per ft., speed 15 r.p.m.
13. Chat rolls, 24 x 18 in., spaced, 40 r.p.m.
14. Tailing elevation, 60 ft. high, 130 ft. 8-ply 20-in. belt; speed speed 400 ft. per min.; upper pulley, 26 in. diam., speed 60 r.p.m.; cups 9 x 6 x 6 in., staggered; spaced 9 in.
15. Rougher jig, 30 x 36 in., 8-cell.

Cells	Speed	Screen	Stroke	Depth of Bed	Pitch of Bridge, in.	Plunger
1	115	¼	1¾	6	¾	Level
2	115	7/16	1	6	¾	Level
3	115	¼	1½	6	¾	Level
4	115	¼	1½	6	¾	Level
5	125	¼	1¾	6	¾	Level
6	125	7/16	1¾	6	¾	Level
7	125	7/16	1¾	6	¾	Level
8	125	7/16	1 7/16	5	¾	Level
16. Cleaner jig, 30 x 36 in., 7-cell.						
1	220	7/32	7/16	6	¾	Level
2	220	¼	7/16	6	¾	Level
3	220	7/32	7/16	6	¾	Level
4	240	7/32	¼	6	¾	Level
5	240	7/32	¼	6	¾	Level
6	240	¼	¼	6	¾	Level
7	240	7/32	7/32	7	¾	Level

Foreign Trade in Copper

Exports of copper from the United States in April, 1917, are reported by the Department of Commerce as follows, the figures for March being given for comparison:

	March Lb.	April Lb.
Ore and concentrates, contents	461,131	516,958
Unrefined, in bars, pigs, etc.	.....	1,738,430
Refined, bars, etc.	102,814,125	102,733,039
Old and scrap	402,752	1,236
Plates and sheets	8,074,657	3,834,546
Wire	3,442,580	2,651,964
Total	115,195,245	111,476,173

The weight of ore exported in April was 4168 tons; of concentrates, 725 tons.

Imports of copper into the United States in April, 1917, are reported by the Department of Commerce as follows:

	March Lb.	April Lb.
Ore and concentrates, contents	10,732,049	14,632,621
Matte and regulus, etc.	218,957	3,617,594
Unrefined, in bars, pigs, etc.	31,799,828	29,600,136
Refined, in bars, etc.	239,291	224,005
Old, etc., for manufacture	1,691,056	1,853,157
Composition metal, copper chief value	47,679	11,330
Total	44,728,860	49,938,843

Material imported in April was 39,634 tons ore, 13,149 tons concentrates and 5231 tons matte and regulus, etc., which came mainly from Canada, Mexico and Chile.

Continuous Drum Filters

BY CARL J. TRAUERMAN
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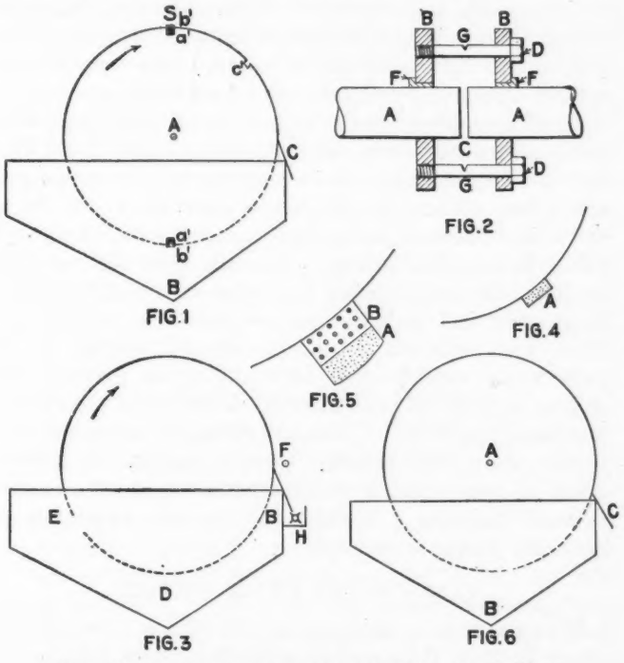
Practical suggestions and information are given as to the operation and maintenance of continuous drum filters such as the Oliver and the Portland. Special attention is paid to winding and cleaning. The advantage of working on thick pulp in preference to thin is emphasized.

IN most of the new metallurgical plants, where filtering is part of the process, and in some of the older plants, one will find the continuous drum filter. Of this class there are two well-known types—the Oliver made by the Oliver Continuous Filter Co., of San Francisco, and the Portland, made by the Colorado Iron Works Co., of Denver.

Having had considerable experience with both kinds, I will give some details of their operation and some "wrinkles" that have been used in time of trouble. I have found that these two filters are identical as to



SKETCHES ILLUSTRATING DETAILS OF DRUM-FILTER OPERATIONS

performance, but differ slightly in construction. It is not meant to "boost" one nor to "knock" the other, but to give facts as found in my own experience.

The driving mechanism of the Oliver is directly attached to the hopper tank, making a more compact and stable arrangement, there being no tendency for it to get out of line, as when installed on an independent foundation.

The Portland filter leaves are already sectionalized when received. They can be quickly installed and are also superior to the Oliver type in other respects. In Fig. 1 the drum is shown at *A*, the tank at *B*, and the scraper at *C*. The drum is divided into sections, the end of each section being sunk as shown at c^1. When the canvas is put on, it is stretched over but one section at a time, a wooden strip, shown at a^1, being inserted into the slot c^1 in each section as it is covered, to hold the cloth fast. Thus a good tight cloth is assured. In the Oliver the cloth is nailed to one section at the start and the tension must be held until it is entirely on, as further tacking may cause leaks at the tack holes in later operation.

Before starting a new drum filter, it is always well to fill the tank with water and revolve the drum for at least 24 hours to swell the wood. During this operation the vacuum should be shut off and the air blowoff allowed to operate intermittently, so as to cleanse the pores of the canvas thoroughly. In rewinding and recanvasing a filter, if there are emergency units, it is well to let the filter leaves dry somewhat after the old cloth has been removed, so that they will swell after the new canvas is in place and thereby make it tighter.

WINDING THE DRUM

In winding the Portland filter an oak winding clamp is used, which serves as a tension at the place where the wire goes on the drum. This mechanism is more compact than that of the Oliver Co., who obtain their tension by passing the wire over several small reels and placing weights on the shafts of the reels. The clamp, however, tends to make the wire wear on the wood, necessitating more watching than the Oliver device, where the tension is more or less constant after once set. When winding either filter, I have found that it pays to have a man at the primary reel and one at the point of winding, as well as one to attend to stapling on the scraper or discharge side of the filter. A man should be kept at the tight-and-loose pulley also, unless there is some mechanism by which the winding man can instantly stop the drum.

The man at the primary reel must be on the alert for kinks, broken wires or sticking of the reel. Many a break in the wire may be saved by seeing that it unwinds freely, and a kink, if noticed quickly, may often be straightened out before reaching the winding man. If there is a broken wire in the reel, the tension may be held by prompt stapling before the broken end passes through the tension apparatus. Most of the troubles in winding are due to these three causes. The primary reel should be quite a distance from the filter, so that wire troubles can be remedied before they reach the tension apparatus. The primary man can usually judge whether this can be done "on the fly" or whether the filter must be instantly stopped for readjustment and splicing of wires.

The wire used on the Portland drum is so much harder than that of the Oliver, that winding it takes more time, because the kinks are harder to straighten without breaking. However, the softer wire wears faster and requires more repairing after operations is begun. With the harder wire most of the wear comes on the soft steel blade of the scraper. These blades should be filed smooth every day as they tend to tooth and, if not filed frequently, will become so ragged that they

will tear the cloth. There is very little wear on the scraper blade of an Oliver, and I have never filed them oftener than once a month.

Another feature of the Portland filter is a thin zinc strip, about one inch wide, which is placed on top of the wooden strip previously mentioned, at two or more points on the drum. This zinc strip, shown at *b*' Fig. 1, makes possible the soldering of the wire winding wherever it crosses the zinc. The winding is usually held on by staples driven into the wooden strips. The less staples there are, the better the filter operates, for when the wood becomes wet the staples tend to loosen and catch on the scraper, causing leaks in the cloth. Should the wire break during operation, two or three rounds must usually be unwound before a staple is found that is still tightly holding it.

Soldering the wire to the zinc strip is done either when the entire winding is over or at intervals during the winding. It should be done with the zinc strip at the top of the drum, position *S*, Fig. 1, as there is then less danger of the hot solder running over the cloth. The cloth should be protected from the solder by passing heavy cardboard under the wires on each side of the zinc strip. After the entire wiring and soldering has been completed, the rough edge of the solder may be filed perfectly smooth so that it will not be torn from the zinc when passing under the scraper. With the winding soldered in this fashion, if the wire does break, it will not slacken beyond the soldered joint nearest the break, and a short piece can be spliced in very quickly. Thus the danger of staple holes is eliminated.

In splicing a wire on an Oliver drum, it is always well to go back a few sections from the point of break. On the Portland it is best to go back one section beyond the zinc strip, thus insuring a soldered as well as a stapled joint.

Stalling of Drums Through Pulp Settling

In drum filters, especially those working on comparatively thin pulp, there is a tendency for the pulp to settle and in time fill the hopper and stop the drum. In the old type of filter, air was used to agitate the pulp in the hopper. I have never found this to be successful, as the air "spots" the cake, making it thin in some places and thick in others, so that washing and drying are not uniform. The new types are equipped with mechanical agitators, placed in the hopper, which are very efficient. However, should anything happen to the agitator, the thin pulp will settle and stop the drum.

Filter men frequently "lean" on the belt to start the drum again when this happens. This usually proves costly. In one such case, during my experience, the worm gear broke and in another the main drum-shaft was sprung. This last-named trouble was remedied by raising the drum shaft by a lever and screw jacks and tumbling it upon its bearings. This was continued for 24 hours, at the end of which time the shaft was true enough to run, although several of the cast-steel uprights holding the leaves were cracked. This, however, did not interfere with the operation of the filter.

Safeguard Against Forcing a Stalled Drum

To protect the gears and shafting against "forcing" when the drum stalls, resort can be had to the device shown in Fig. 2. The Portland driving shaft is coupled with a flanged coupling keyed to the shaft, the flanges being held together with four bolts, which screw into threads in both halves of the coupling. In Fig. 2 the shaft is shown at *A*. The keyway in the shaft should be lengthened on both sides of the coupling and the flanges slid back until they are about two inches apart. The two ends of the shaft should be about $\frac{1}{8}$ in. apart. The flanges *B* should then be keyed to the shaft as shown at *F* and fastened together with bolts about four inches long, as at *D*. These bolts, which are about $\frac{3}{8}$ in. in diameter, are first sawed half through as shown at *G*. Forcing a stalled filter, so equipped, will result simply in shearing the bolts.

Under normal conditions the half-sawed bolts will be found strong enough, as the power required to rotate the drum is small. Both Portland and Oliver filters are geared very high. If the bolts should break, it usually means that the hopper needs sluicing out. The more quickly this is done the more time one will gain in filter operation. It is well to keep a stock of these half-sawed bolts on hand, so that no time will be lost in starting up again.

If a filter is idle, the drum should be kept running in the solution left in the hopper to keep it wet. In operating a small group of filters it is better, I believe, to have each one connected to its own vacuum pump rather than to have one pump for the whole group. The reason that I advocate this is because I have never seen a valve that will absolutely cut off vacuum.

I had occasion to run a bank of two drum filters, each with a vacuum pump, but with the vacuum lines connected to each other. The connecting pipe had two cutoff valves. When one filter was shut down, we closed down one vacuum pump and shut off both the cutoff valves in the pipe between. The idle filter was revolved in very thin pulp to keep the drum wet. I found that there was still a little vacuum working on the idle filter, just sufficient to pick up the fine slimes in the pulp, which were hard to blow out of the pores of the canvas and caused poor filtering later unless the canvas was first scrubbed. I found it better to sever the connection completely between the two pumps. If a valve could be found that would completely shut off vacuum, it would then be a distinct and obvious advantage to have the pumps connected.

Cleaning the Filter Surface

Where a filter is working on thin pulp or in a solution heavy in lime, it is well to scrub the filters frequently. A good root brush should be used, and in case of lime solution it is better to scrub with weak hydrochloric acid. Where acid is to be used, it is best to empty the hopper as much as possible and to do all the scrubbing from the top of the filter while it is revolving. A man should be kept on the scraper side of the filter to wash off the acid with a hose. Scrubbing may be done by attaching several brushes to a board running the width of the drum. The board and brushes may be drilled so that water or acid solution can be poured down into the brush. A right-and-left-hand screw tension may be placed at the ends and middle of the board, so as to press the brushes down. The scrubbing solution may be applied from a tank or by hand. Scrubbing of this sort is uniform and well done. A spray may be installed on the discharge side of the filter to wash off

the acid and thus make the scrubbing entirely automatic, by simply revolving the drum.

I was once referee in an argument over the quality of the canvas on certain filters. I found that the canvas tended to slit under the wires and that it had to be replaced every 30 days. Whenever the cloth rips under the wires, it is unusually due either to failure to wash out all the acid from the cloth after an acid scrubbing or to the strength of the air blowoff which removes the cake. In this case I found that 10 to 15 lb. air pressure was being used to dislodge the cake. I believe this is too much. I installed a small receiver and an air reducer and cut the pressure down to between two and four pounds and found this to be very efficient. After this installation the cloth lasted from four to six months.

Sluicing Out the Filter Cake

Wet sluicing of filter cake will be troublesome where one does not use a conveyor to dry the discharge and where water is scarce. In one plant I found that the cake dropped into a launder box, from one end of which a hose sluiced the cake down the launder. The fall of the launder was small, and eleven parts of water to one of cake were needed to keep it clear. This was remedied in the following way:

A 2-in. pipe was bored with holes about four inches apart. Through each hole a soft iron rod was run, extending about three inches beyond the pipe on each side. The ends of the rod were then flattened like paddles. The pipe was set in wooden bearings in the launder box below the scraper, as shown at *H*, Fig. 3. By rotating it, a better mixture of cake and water was obtained. A water-spray pipe was installed at *F* in Fig. 3. This spray and the mixer facilitated our tailings discharge so that only three parts of water to one of cake were used and in time of low water even less with good results.

Thick Pulp Means High Efficiency

In order to obtain full efficiency from a drum filter, it must work on thick pulp. Where pulp settles readily, I have always found it cheaper to buy a Dorr thickener than to put in an additional filter. I have had frequent occasion to settle pulp running 25% solids to one running 50% solids or better. It is hard to do this continually; that is, by one stage thickening with the lower outlet of the thickener open at all times. The greatest success was attained by using a series of Dorr thickeners about eight feet deep (each) and drawing from one while another was filling and thickening.

In Fig. 4 is shown a section of the cake on the filter when the pulp is thin, demonstrating that nothing but the fine portion of the slimes will then adhere to the filter. When working on thin pulp, it is the rule to have the hopper tank almost full in order to obtain good work from the filter. When the drum is at the point *B*, Fig. 3, the filter is drawing very thin solution through the canvas, but as it goes to the point *D* a cake similar to *A*, Fig. 4, is picked up, which is only the finest portion of the slime. The heavier portion of the slime settles in the hopper and, if not agitated, will in time stall the drum, and may do so even with agitation. The fine cake so clogs the pores of the cloth that there is no more pulp added to the cake between the points *D* and *E*, Fig. 3, and all filtering and drying action is largely suspended. All this time the cake is immersed in solution, and the result is that one gets a thin cake, which is very moist when discharged. If wash is used, the cake does not get a sufficient cleansing. Frequent scrubbing of the filter, because of the clogging of the canvas pores, is also made necessary.

With thick pulp the same capacity can usually be obtained by filling the tank only about 14 in. to 18 in. deep, as can be gained by filling it full. When the drum reaches the point *D*, Fig. 3, it forms a cake, shown in Fig. 5. The heavy granular portion of the slime *B*, Fig. 5, will be drawn on the canvas first and will make an ideal filtering medium for the lighter portion *A*, Fig. 5. This makes an ideal cake and a thick one. Shortly after leaving *D*, Fig. 3, the drum emerges from the pulp and the cake undergoes a drying action from that point until it is discharged or, where washing is resorted to, until it strikes the water spray at the top of the filter. Such a cake usually leaves the filter well washed and low in moisture.

I do not think such a deep receiving tank is necessary with a filter working on thick pulp. I think a shallower tank, as shown in Fig. 6, would suffice. With such a tank the discharge scraper could be placed farther down and thus insure a longer drying period in the cycle and drier pulp. A shallower tank also ought to cost less.

Thin Pulp Versus Thick Pulp

Appended are some figures covering the operation of a 16-ft. face 11½-ft. diameter drum filter working on two classes of pulp at a cyanide plant where a water wash was used at the top of the filter. The filter was not equipped with a mechanical agitator.

TABLE SHOWING CAKE MADE FROM THICK AND THIN PULP

Hours' Time	Pulp, % Solids	%-200-Mesh Pulp	Filtered, Dry Tons	%Moisture, Cake	%-200-Mesh Cake
8	35	80	35	20	94
8	55	79.7	051	12	80.5

These figures are typical of my experience with drum filters working on thick and thin pulp.

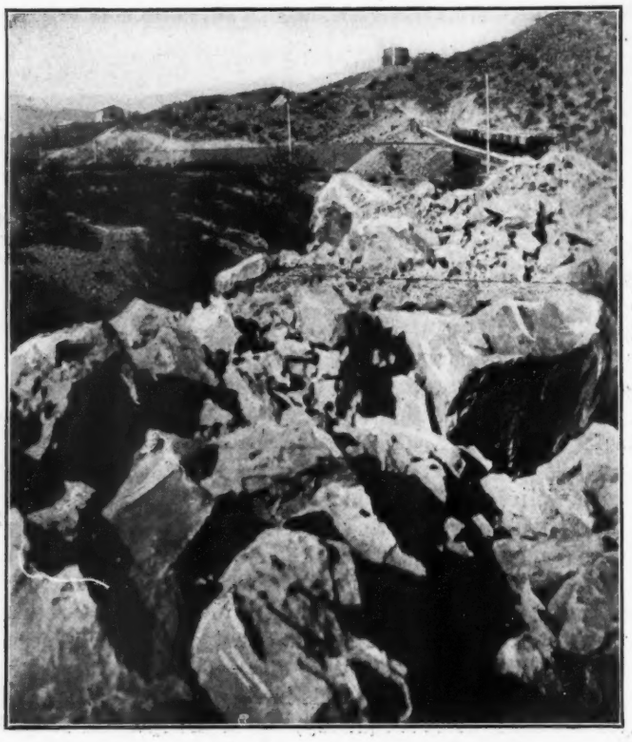
As to water-wash control, there is not much to be said where thick pulp is used with low submergence in the receiving tank. For other cases this feature has been well described and a remedy suggested by E. E. Carpenter, in "Cyaniding Practice of Churchill Milling Co., Wonder, Nev.," Trans. A. I. M. E., Vol. LII, p. 133. However, I have found it better to use spray water from a low-presure tank rather than from a high-pressure water line. In installing a low-pressure tank it is best to screen the outlet so that no dirt will flow to the spray pipe and clog the holes. This is very important because the holes will close frequently, and if the operator is not continually on the jump, the pulp will get an insufficient wash.

Estimating the Position of Oil and Gas by chemical analysis of the water encountered in drilling is shown to be possible by recent work done by the United States Geological Survey in the California oil fields (Bulletin 653, "Chemical Relations of the Oil-fired Waters in San Joaquin Valley, Calif.," by Sherburne Rogers). Investigations have shown that the deep seated waters associated with oil in the California fields are different from those found near the surface as well as from the deeper waters outside the field.

Crushing at New Cornelia

By David Cole
Specialist in ore concentration, El Paso, Texas.

The New Cornelia Copper Co. is not confronted with a "capping" problem. There isn't any waste. A very large part of the orebody stands out in the open with daylight all around it, so to speak. Three small porphyry mountains immediately adjacent to one another, bare of vegetation and covered with an epidermis of mottled brown, constitute the mine, and a most convenient arroyo meanders into the middle of the group and affords ideal sites for the "pits" and for tracks to accommodate the big Marion shovels which are now rooting their way into the ore. The brown surface color is only "tan" and everywhere gives way to gray and green at the first shots. The usual churn-drill rig for blasting purposes is missed, for piston drills are used in stirring up the ground ahead of the shovels. These drills handle steels up to 32 ft. in length, and lifters are mostly used for placing the explosive to best advantage. Standard-gage, side-dump cars of 20-cu.yd. capacity and very latest pattern receive anything that will go through the dippers of the shovels. The haul from pit to crushing plant is short. The grades are easy, making movements cheap



COARSELY BROKEN ORE AT THE NEW CORNELIA

and fast. Very little block-holing is necessary because in the crushing plant there is a primary breaker big enough to handle any piece of rock the shovels can.

A No. 24 Gates gyratory breaker, capable of handling the largest sizes of rock while reducing it to 9-in. cubes at the rate of 800 or more tons per hour, is used. This crusher discharges on two sides into four No. 8 gyratory auxiliaries grouped around its base. Each pair is served by a 3-ft. belt conveyor to carry the final product of the plant at 3½ in. maximum size into a 10,000-ton crushed-ore storage bin.

The railroad track leaves the hillside on a trestle and passes centrally over the big crusher on a removable-girder span. The cars are dumped directly into the big ore-cushioned funnel which leads into the maw of the machine. This hopper is a large square room of steel, the corners filled with ore left at the angle of repose. Bridging the neck of the funnel lengthwise, the track is a great spider-beam acting as a fulcrum for the suspended spindle of the crusher, which looks unusually small when contrasted with the crater it is in.

Dumping these 40-ton cars of ore into this funnel is without spectacular effect. The beam and spindle disappear; the mass squirms for a brief period, and is gone. The slowly gyrating spindle emerges from the mass ready for the next onslaught immediately following on the other side. There is little noise (much less

THE NEW CORNELIA COPPER CO.'S ORE CARS

than one would expect), and there is little dust because the cars have received a drenching of water while en route. Thus the ore is automatically finished in two breaks from the maximum size, as shown upon the car, to 3½-in. cubes ready to be briefly stored for feed to the fine-crushing plant. Five thousand tons, the capacity of the leaching plant, is handled in 8 hours, and the side-dump trains are used at the leaching vats on another shift for taking away tailings.

The trippers over the storage bins have magnetic head pulleys for removing tramp iron and steel. They also have water sprays which travel with them to add the amount of moisture the crushed mass will absorb without becoming wet or sticky to embarrass handling later on.

The storage bin is a looped steel box, the concrete floor of which is carried upon a group of massive pillars of concrete. There is daylight all around, for it is all above the ground. The bin is emptied by four rows of arc bin gates correctly spaced properly to draw the ore, and these are served by four conveying belts that carry feed to the respective sections of the adjacent plant where the final finishing is done. Four automatic feeders, having their own locomotive features, serve these belts, operate electrically, and are adjusted to give each section of the fine-crushing plant the right amount of feed. As the ore falls from the ends of the conveying belts into the crushers, it passes over magnetic head pulleys for the second time to insure the most complete removal of steel from the material to be fed into the fine-crushing machines.

After much experimentation and study, Symons disk crushers were selected for the finishing work. They promised to make less fines and slimes, require less space and power, and cost less for repairs. They were especially redesigned to fit the work in hand. Each machine has its individual motor direct-connected through flexible coupling, and they are arranged in groups of three, with motors in ventilated galleries by themselves. There are four sections of this kind in which no wheels or belts are seen. The 3½-in. maximum size cubes are reduced in two stages to proper leaching size, which is minus ¼-in. square hole, and the work is so well done that very little will lie on a screen with openings of this size. The ground space covered by the fine-crushing plant is but 130 x 66 ft., and the capacity is 5000 tons in 16 hours, with one section to spare.

This arrangement of fine crushers is an interesting departure from usual practice and is the first one of its kind. It deserves a more detailed and extended description than is possible at this time, but it doubtless will be available later on, with interesting details, especially as to costs.

Report of Copper Production

This table is compiled from reports received from the respective companies (except in the cases noted by asterisk as estimated), together with the reports of the United States Department of Commerce as to imported material, and in the main represents the crude-copper content of blister copper, in pounds.

	March	April	May	June
Alaska shipments	10,959,696	10,585,518	7,146,824	.....
Arizona:				
Arizona Copper	5,000,000	5,000,000	5,200,000	.....
Cons. Ariz. Smelting	1,750,000	1,650,000	1,650,000	.....
Inspiration	11,100,000	11,400,000	11,900,000	11,150,000
Miami	5,338,000	5,364,000	5,112,000	5,349,000
Old Dominion	3,335,000	3,516,000	4,430,000	3,965,000
Ray	8,006,843	7,902,724	8,815,281	.....
Shannon	950,000	924,000	964,000	956,000
Other Arizona	30,394,138	26,995,962	25,954,310	*24,984,675
California:				
Mammoth	2,000,000	1,850,000	2,000,000	1,800,000
Michigan:				
Calumet & Hecla	14,949,919	14,347,181	14,450,011	.....
Other Lake Superior*	9,500,000	9,000,000	8,500,000	.....
Montana:				
Anaconda	31,300,000	29,300,000	28,400,000	20,400,000
East Butte	1,597,340	2,081,080	2,008,060	1,519,240
Nevada:				
Mason Valley	1,821,695	1,300,000	1,528,813	.....
Nevada Cons.	6,864,675	6,727,192	7,239,978	.....
New Mexico:				
Chino	6,200,851	6,368,874	6,984,457	.....
Utah:				
Utah Copper	15,512,676	17,231,512	19,262,856	.....
Eastern smelters*	2,762,825	2,386,855	2,521,800	.....
Total reported	167,593,648	163,930,898	163,068,390	.....
Others, estimated	24,618,000	24,755,000	24,682,420	.....
Total United States	192,211,648	188,685,898	187,750,810	.....
Imports, ore and concentrates	10,951,006	18,250,215	.....	.....
Imports in blister, etc.	32,039,119	29,824,141	.....	.....
Grand total	235,201,773	236,760,254	.....	.....
British Columbia:				
Canada Copper Corpn.	406,072	352,732	270,816	.....
Granby Cons.	3,901,398	3,775,140	3,159,284	.....
Mexico:				
Boleo	1,984,080	1,653,680	1,929,088	.....
Cananea	5,500,000	4,730,000	4,370,000	.....
Other Foreign:				
Braden	5,942,000	5,102,000	6,750,000	.....
Cerro de Pasco	6,074,000	5,936,000	4,670,000	5,032,000
Chile	8,714,000	8,028,000	8,250,000	.....
Cape Copper	387,520	353,920	396,825	.....
Kyshtim	985,600	1,110,000	.....	.....
Katanga	5,996,510	5,070,580	5,643,775	5,246,950

* Estimated.

The grand total, which in the case of March was 235,201,773 lb., includes, under "Imports in ore and blister copper" the production of such companies as British Columbia, Granby, Cananea, Braden, Cerro de Pasco and Chile. As a matter of record, however, the figures are repeated after the total. We also report the production of the Boleo, Cape Copper, Kyshtim and Katanga companies, whose copper does not come here.

The item "Alaska shipments" gives the official figure of the United States Department of Commerce. Kennecott production February-May was 7,090,000 lb.; 7,076,000; 7,180,000; and 7,208,000 lb., respectively.

Efficiency of Screens

BY HAROLD RABLING*

The efficiency of any screening machine, such as a trommel or shaking screen, is equivalent to the ratio between the amount of ore passing through the screen and the amount that would pass through if all the grains in the feed were tried separately in all positions. It may be obtained by measuring the tonnages of feed and products and sizing by hand a sample of the feed on a sheet of material similar to that on the screen. Let

X = Tons of feed per day;
Y = Tons of undersize per day;
A = % of coarse material in the feed sample;
B = % of fine material in the feed sample.

Then Y = the tonnage that passes through the screen, $\frac{B}{100}X$ = the tonnage that should pass through, and the efficiency $= \frac{100Y}{BX}$

It is sometimes inconvenient to measure tonnages, and they may be eliminated by using the following method: Take samples of the feed and oversize, and size them as before on a sheet of the screening material. Let

A = % of coarse material in the feed;
B = % of fine material in the feed;
C = % of coarse material in the oversize;
D = % of fine material in the oversize;
X = Tons of feed per day;
Y = Tons of undersize per day;
Z = Tons of oversize per day.

All the material in the feed that is larger than the screen opening will pass to the oversize and is equal to $\frac{A}{100}X$ tons per day. The oversize will therefore consist of $\frac{AX}{100}$ tons of coarse material, together with a certain amount of fine material that escaped being caught. The sizing tests show that coarse material comprises C% of the oversize, whence the following equation is obtained:

$$\frac{C}{100}Z = \frac{A}{100}X, \text{ or } Z = \frac{AX}{C}$$

The tonnage of undersize $Y = X - Z = X - \frac{AX}{C}$

$$X\,\frac{C-A}{C}$$

The efficiency of the screen

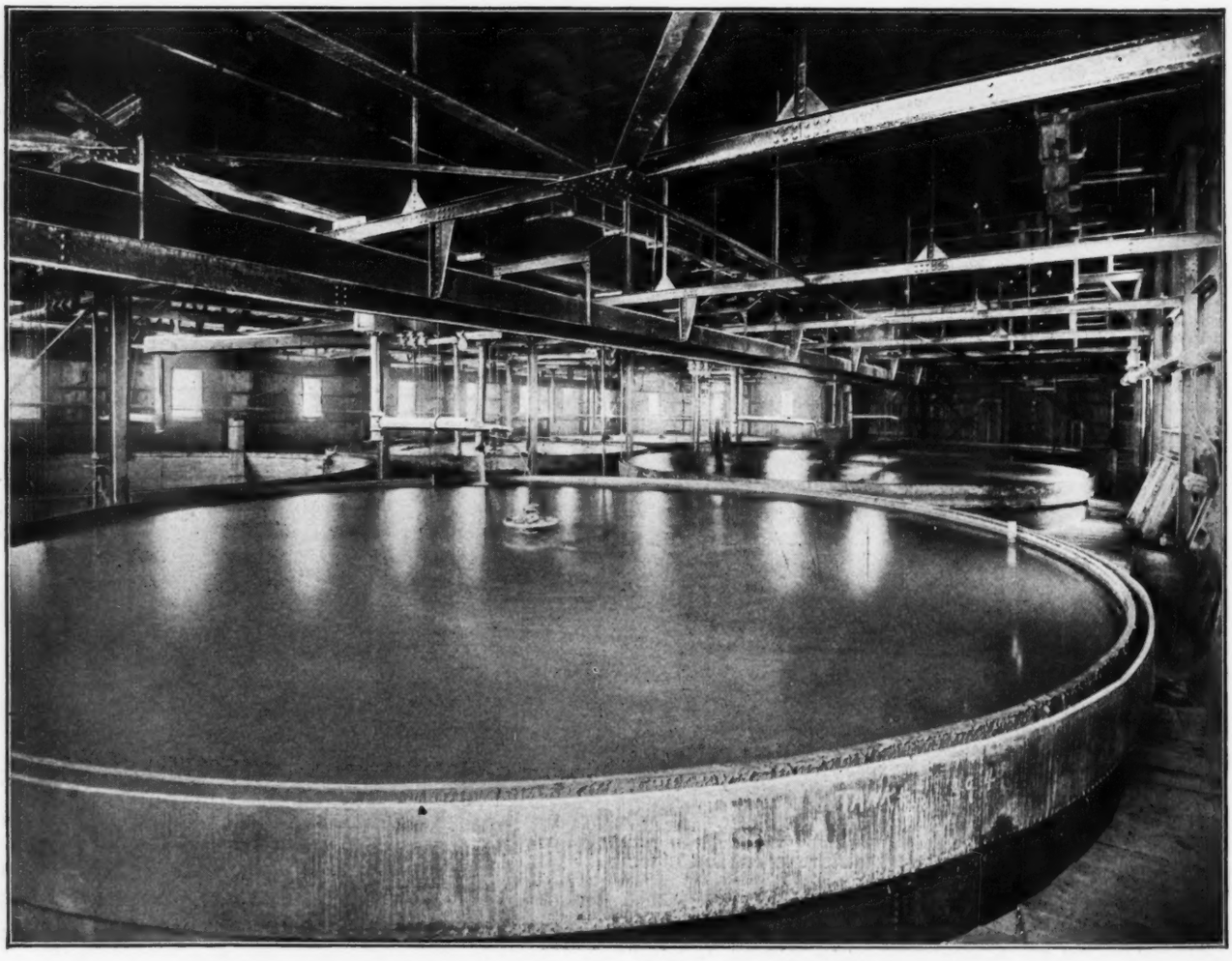
$$= \frac{\textit{tonnage of undersize}}{\textit{tonnage of fine material in the feed sample}}$$

$$= \frac{X\frac{C-A}{C}}{\frac{B}{100}X} = 100\,\frac{C-A}{BC}$$

*Metallurgist, Bonne Terre, Mo.

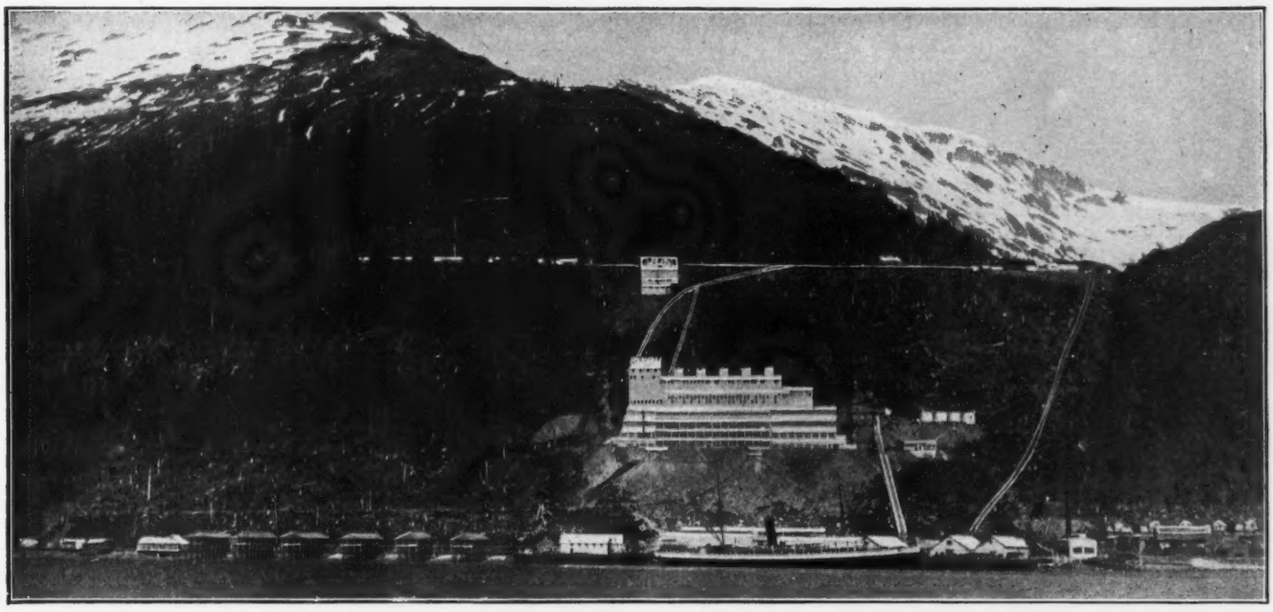
Some Important Gold

THE 1300-TON MILL OF DOME MINES, LTD., IN THE PORCUPINE GOLD DISTRICT. NORTHERN ONTARIO

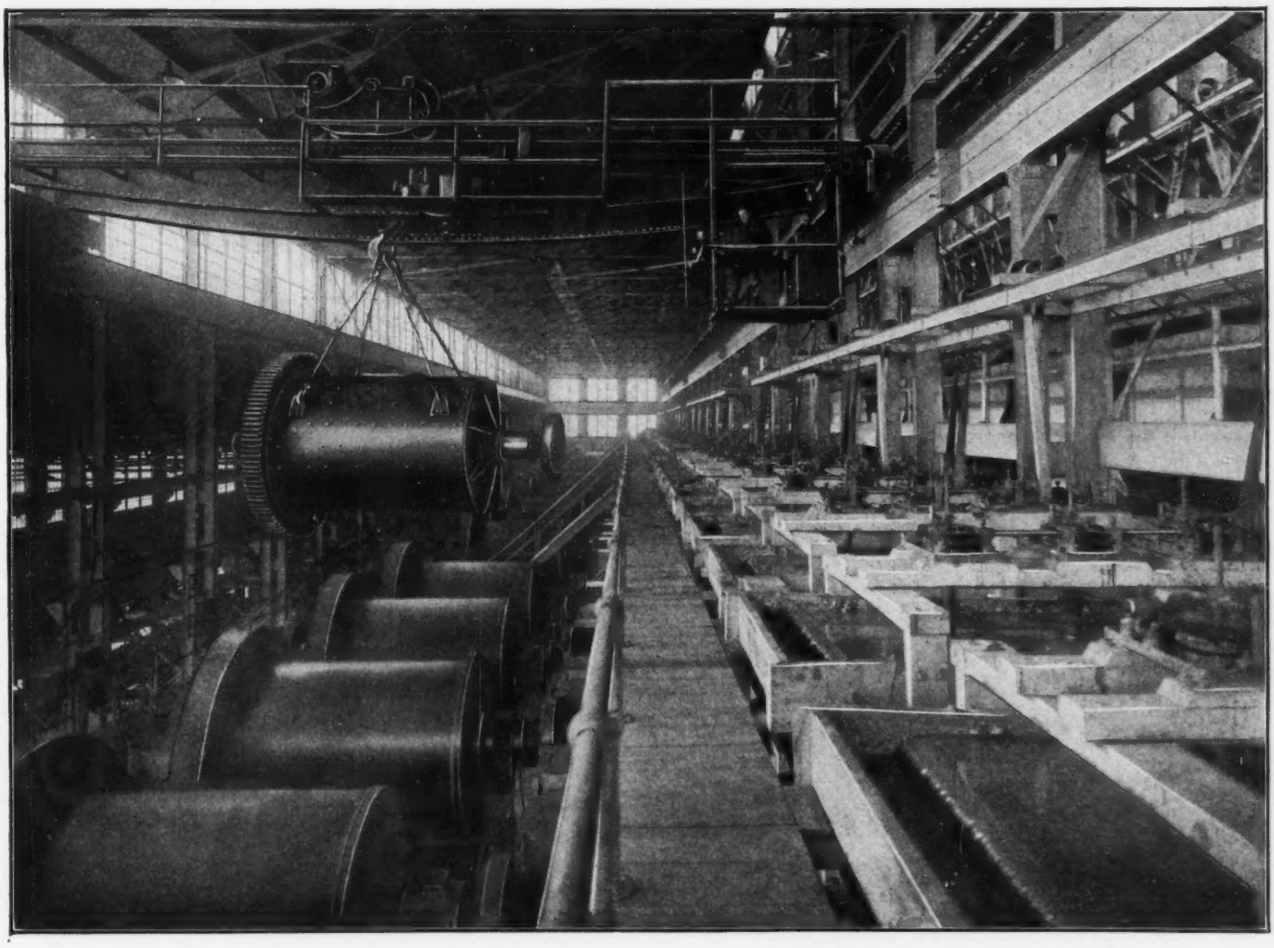


SAND LEACHING TANKS IN THE DOME MILL AT SOUTH PORCUPINE, ONT.

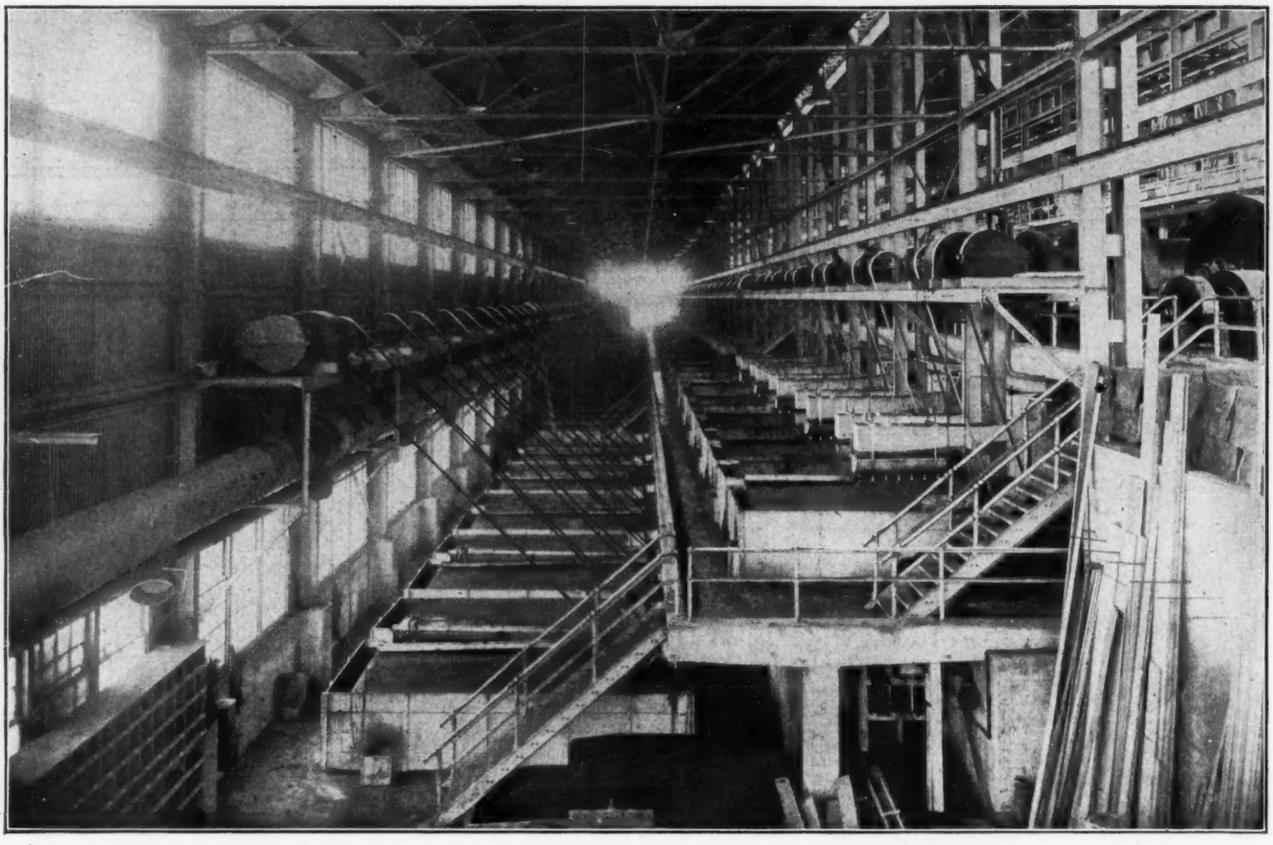
Mills of North America



ALASKA GASTINEAU MINING CO.'S 10,000-TON MILL AT THANE, ALASKA

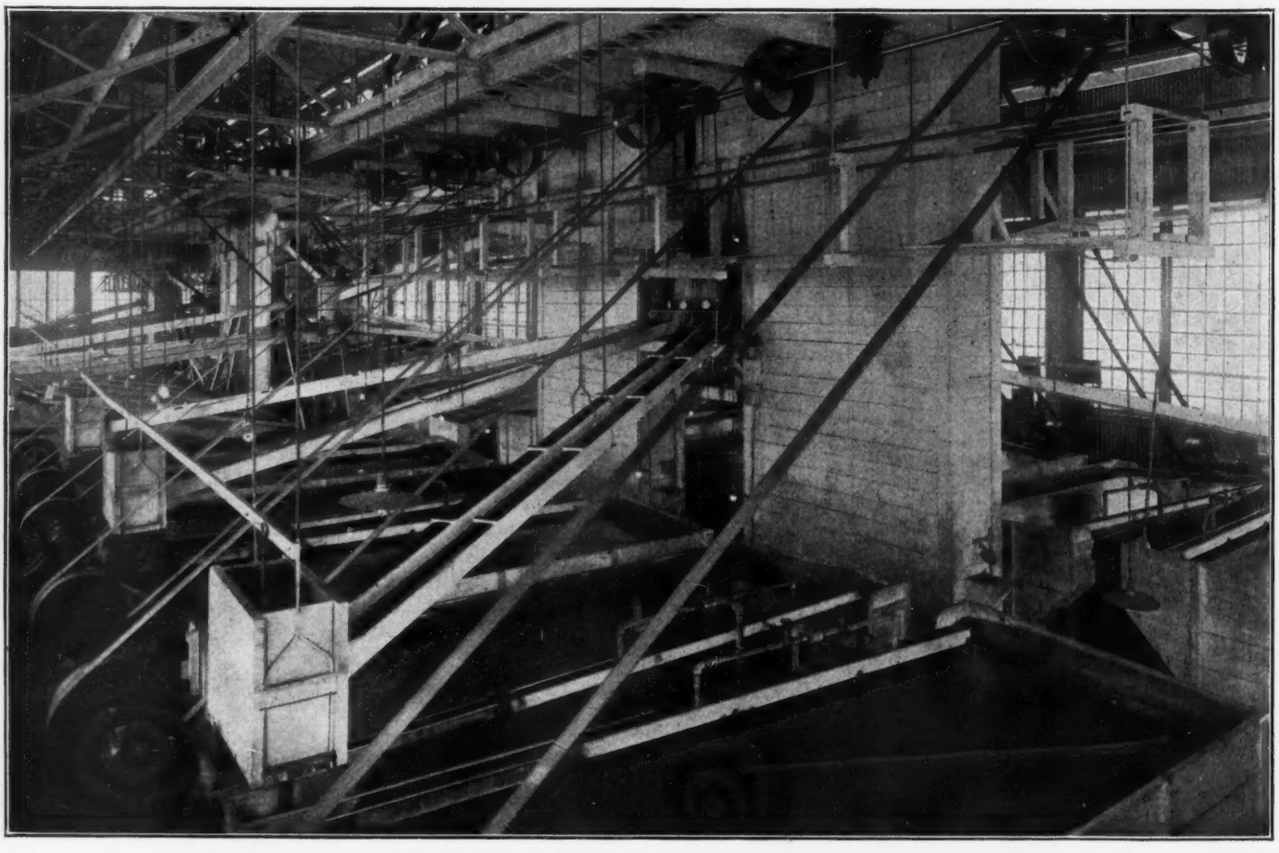


TUBE-MILL SECTION OF ALASKA GASTINEAU MILL, CONTAINING TWENTY 7 x 10-FT. MILLS

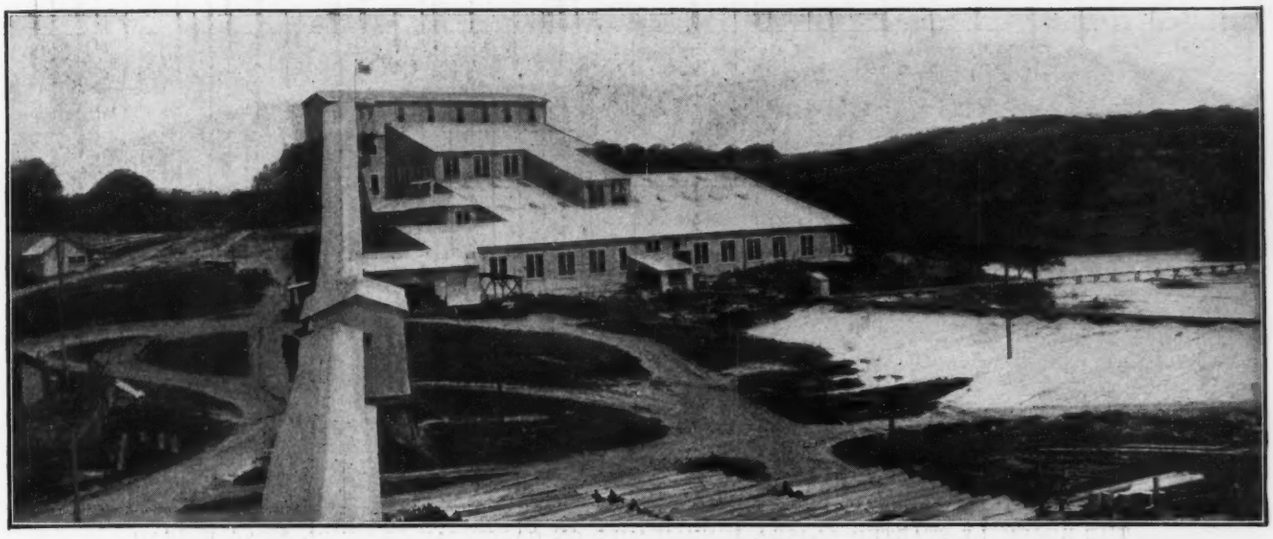


SECONDARY-ROUGHING AND CONCENTRATING FLOORS IN ALASKA GASTINEAU MILL, JUNEAU DISTRICT

The product from the twenty 7 x 10-ft. tube mills shown on the preceding page is handled on 40 double-deck Garfield roughing tables, the rough concentrate of which is finished on 40 No. 5 Wilfley tables. The iron and lead concentrate produced in the concentrating department is reconcentrated on 24 Wilfley tables shown in the view below



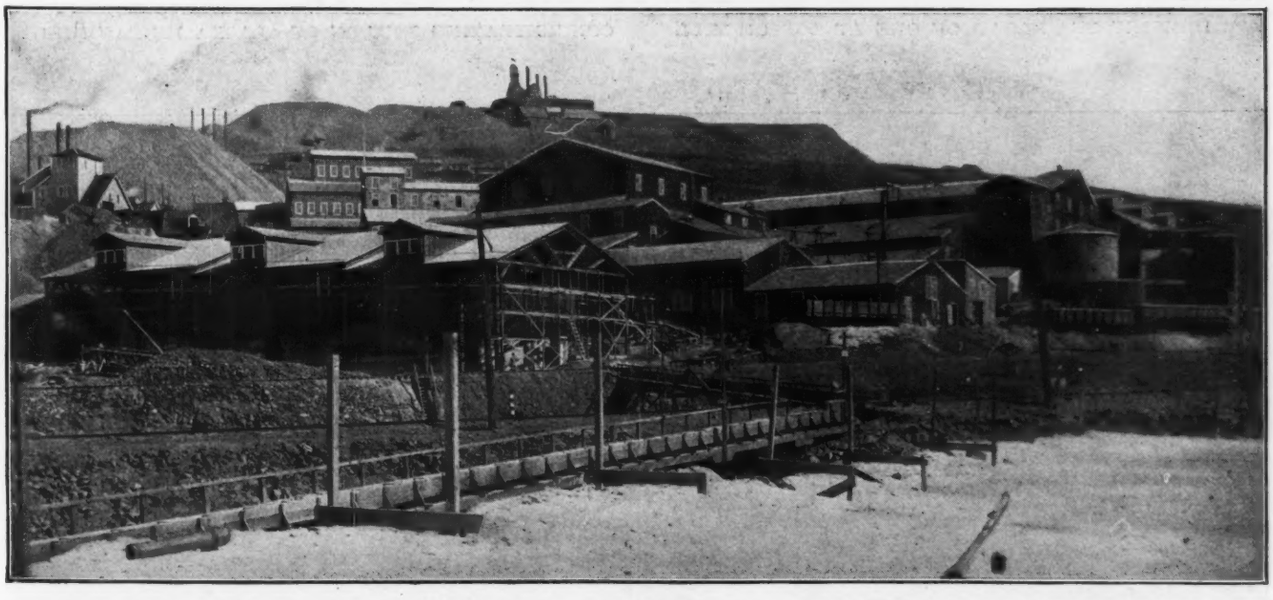
UPPER FLOOR, RETREATMENT DEPARTMENT, ALASKA GASTINEAU MILL, THANE, ALASKA



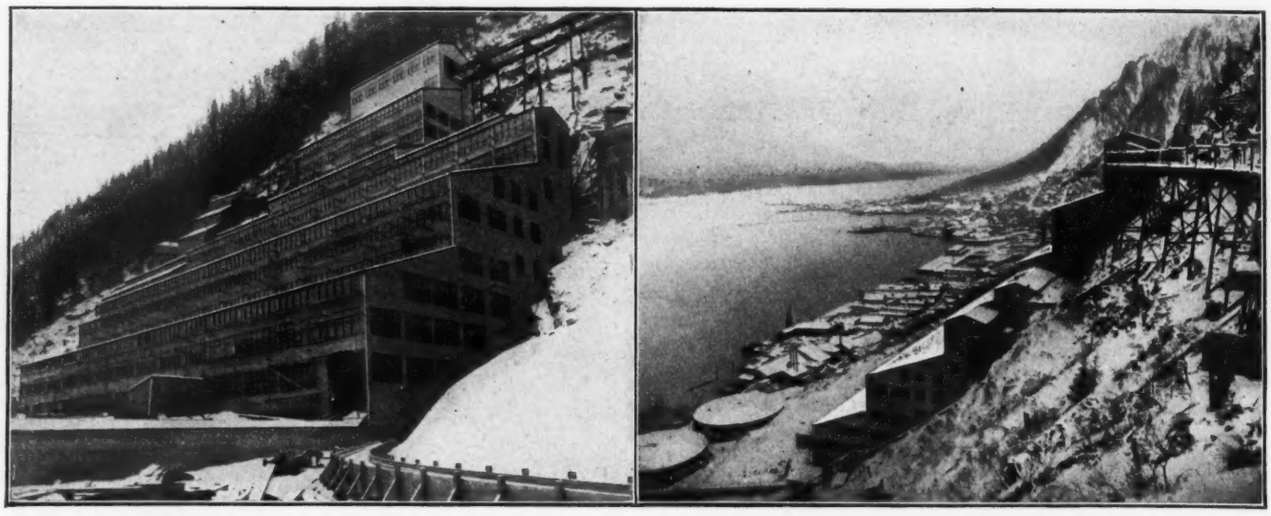
MILL OF THE PLYMOUTH CONSOLIDATED GOLD MINES, LTD., AMADOR COUNTY, CALIF.

This old Mother Lode producer after lying idle about 30 years, was reopened by a British company on the recommendations of W. J. Loring and Albert Burch. It has been yielding steadily since August, 1914, when the new mill was placed in operation, following unwatering and exploration in the old mine. About 11,000 tons are milled monthly for a yield of about $60,000. Since reopening the mine has produced over $1,850,000 and its success has stimulated the opening of a number of other old gold mines in California

THE PORTLAND GOLD MINING CO.'S OLDER MILL AT VICTOR, COLO.

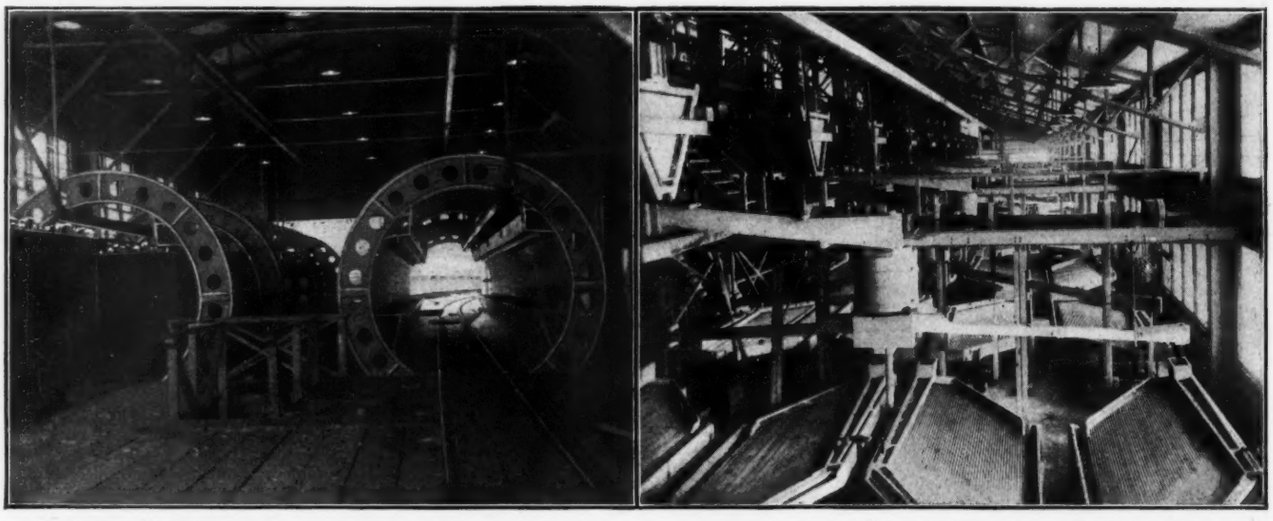


THE NEW PORTLAND MILL—THE REMODELED INDEPENDENCE MILL—WITH PORTLAND SHAFT NO. 1 IN BACKGROUND



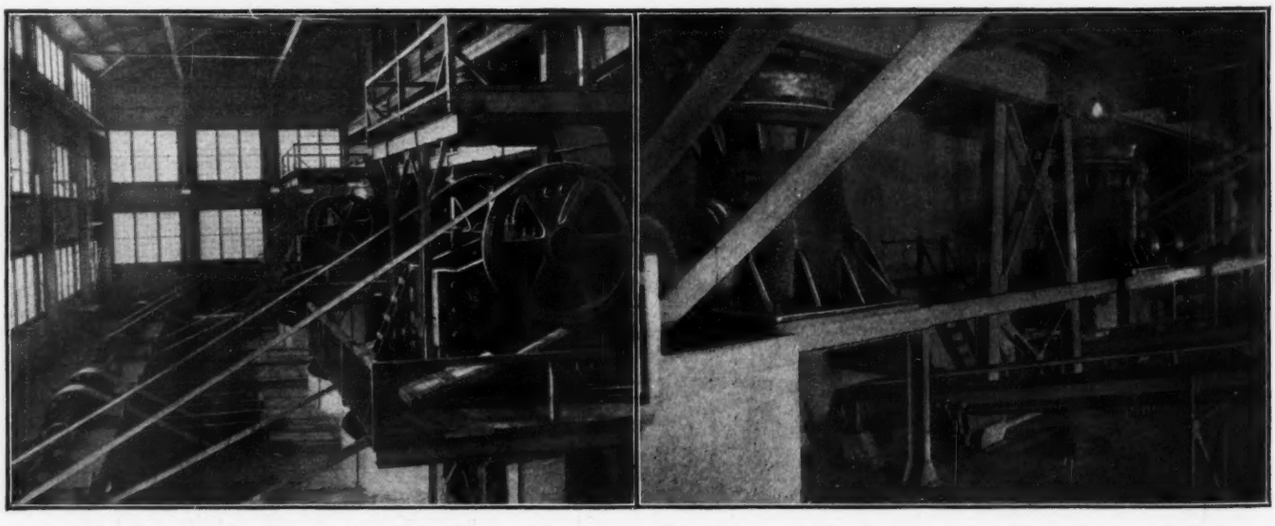
THE RECENTLY STARTED ALASKA JUNEAU MILL ON GASTINEAU CHANNEL, NEAR JUNEAU

This new gold mill was started in April and is gradually being brought up to capacity. While the grade of ore in the Juneau gold belt has proved disappointing, as mined to date, the mills of this district are giving highly satisfactory results. The Alaska Juneau mill has a nominal capacity of 8400 tons per day, but the company expects by the end of the year to have raised the output above the rated capacity. Crushing is done in jaw and gyratory crushers, followed by ball mills and tube mills. The gold is recovered by table concentration

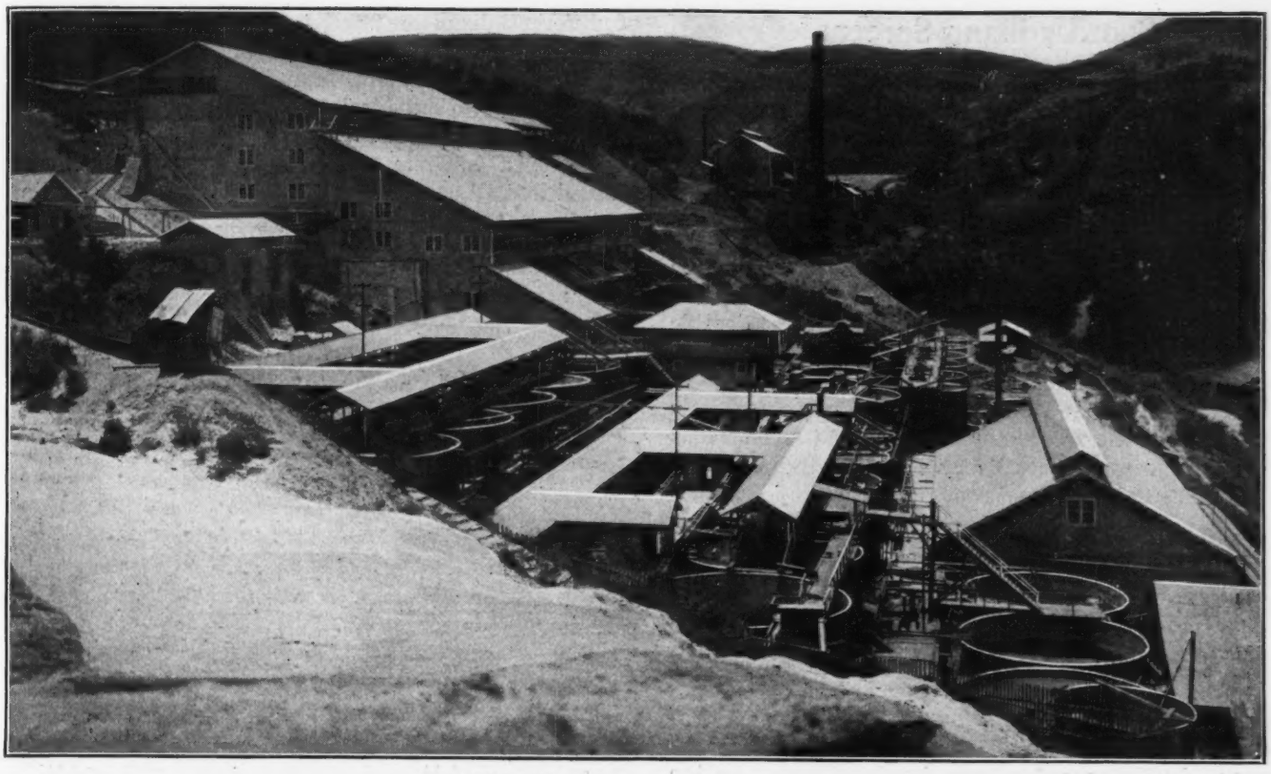


DUMPING TRAINLOAD OF ORE AT TOP OF MILL

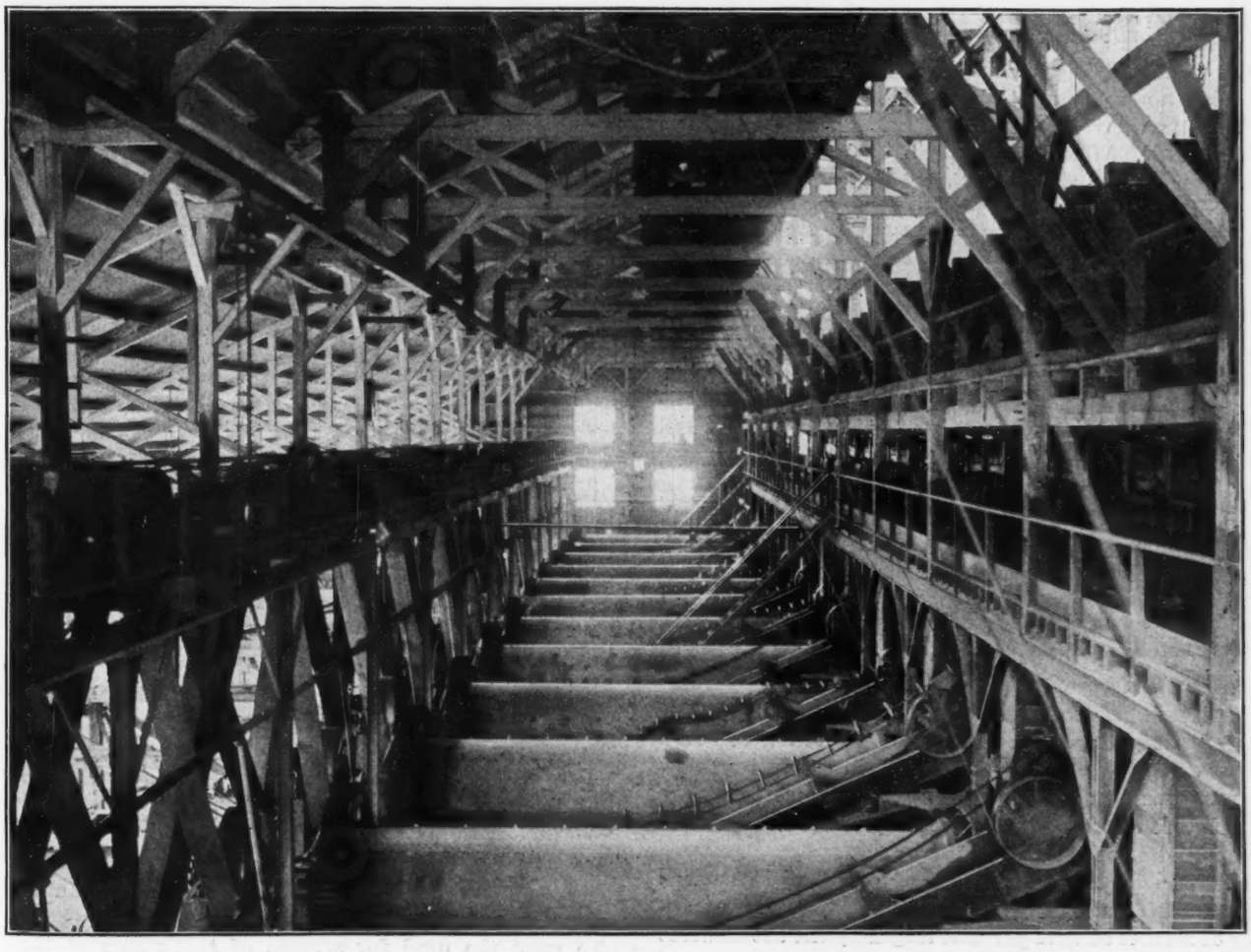
CONCENTRATING SECTION OF ALASKA JUNEAU MILL



JAW CRUSHERS GIVE ORE PRELIMINARY CRUSHING, AFTER WHICH IT IS PASSED TO GYRATORY CRUSHERS



DOS ESTRELLAS MINING CO.'S 1000-TON EL CEDRO MILL, EL ORO DISTRICT, MEXICO



TUBE-MILL FLOOR OF EL CEDRO MILL OF THE DOS ESTRELLAS CO., EL ORO, MEXICO

Eleven of the 14 tube mills are shown in this view, with drag classifiers of the modified Esperanza type, and the stamp batteries at the right-hand side of the illustration. The size of the tube mills is 24 x 5 ft. Each is driven at a speed of 29 r.p.m. by a 75-hp. motor, for an output of about 70 tons per 24 hours, 85% passing through 200 mesh

Standardizing Screens*

Because of the frequent requests received by the United States Bureau of Standards that screens of other sizes than the standard 100- and 200-mesh be tested and certified, a study of the subject was undertaken by the bureau. Opinions of manufacturers were sought as to the desirability and practicability of different screen scales. A scale useful to all industries, making fineness tests, was the end in view. As a result a conference was called at the Bureau of Standards, Apr. 20, 1916, of representatives of the various technical and scientific societies and trade organizations as well as of all the Government bureaus concerned.

This conference adopted as a standard screen scale that given in the accompanying table, and recommends that it be adopted generally by scientific, technical and engineering soicieties and committees, and by branches of National, state and municipal governments as a part of their specifications for materials and methods of test; also that it be used by private firms who have need of standard screens.

Explanation of the Screen Scale

In the table is given, in the first column headed "Opening," the width of the opening (on the first line in millimeters, on the second line in inches) for each screen. In the second column, headed "Mesh," on the first line is given the number of meshes per linear centimeter, and on the second line the equivalent number of meshes per linear inch. In the third column, headed "Wire Diam.," is given on the first line the diameter of wire in millimeters, and on the second line its equivalent in inches. In the fourth column, headed "Ratio Wire Diam. to Opening," is given the ratio of the wire diameter to the width of the opening between wires. In the fifth and sixth columns, headed "Tolerances," are given the tolerances for these screens mentioned in the specifications below. These tolerances will, for testing purposes, be used essentially in the metric dimension, but on the second line in each case is given their equivalent in inches in order that they may be compared readily with tolerances in previous use. The tolerance in the fifth column is that for the meshes per centimeter and per inch respectively, and in the sixth column the tolerances for wire diameter in millimeters and inches, on the first and second lines respectively.

The series has been made large enough, it is hoped, to meet the needs of all industries. Some industries may have occasion to use all the screens in a certain section of the series and none of the others, while in other industries it may be desirable to use only certain screens selected from the whole range of the series. In making selections of screens from this scale for various industries it is recommended that this be done on some systematic plan, as for example, the selection of every other screen or of every fourth one in the series below 1 mm. opening and every other screen above 1 mm., in which case the ratio of each opening to the next smaller one would be as 2 to 1.

Because of the wide range of openings in screens now manufactured which are possible with a given number of meshes of wire per unit length by the use of wires of different diameters, and the consequent confusion and uncertainty which arises in designating screens by the number of meshes per unit length, the screens of this series have been designated by the width of the opening in millimeters, as for example, a 1.41-mm. screen, or a 0.36-mm. screen. It is urgently recommended that all users of screens in the future designate these standard screens in this way and that the manufacturers mark and list the screens in this manner rather than by the meshes per inch.

To meet the need for screens of this series at the present time, a temporary provision has been made in the specifications for the acceptance of screens of slight-

TABLE OF STANDARD SCREEN SCALE

Based on a 1-mm. opening screen with the square root of 2, or 1.4142, as the ratio of the openings of successive screens coarser than 1 mm., and the fourth root of 2, or 1.1892, as the ratio of the openings of successive screens finer than 1 mm.

	Opening	Mesh	Wire Diam.	Ratio Wire Diam. to Opening	Tolerances Mesh	Tolerances Diam.
8-mm. Screen:						
Metric	8.00	1.0	2.00	0.25	±0.01	±0.08
Customary	0.315	2.54	0.079	. . .	±0.03	±0.003
5.66-mm. Screen:						
Metric	5.66	1.4	1.48	0.26	±0.01	±0.08
Customary	0.223	3.56	0.058	....	±0.03	±0.003
4-mm. Screen:						
Metric	4.00	2.0	1.00	0.25	±0.02	±0.05
Customary	0.157	5.1	0.039	....	±0.05	±0.002
2.83-mm. Screen:						
Metric	2.83	2.75	0.81	0.29	±0.02	±0.05
Customary	0.111	7.0	0.032	....	±0.05	±0.002
2-mm. Screen:						
Metric	2.00	3.9	0.56	0.28	±0.04	±0.05
Customary	0.079	9.9	0.022	....	±0.1	±0.002
1.41-mm. Screen:						
Metric	1.41	5.0	0.59	0.42	±0.08	±0.025
Customary	0.0555	12.7	0.0232	....	±0.2	±0.0010
1-mm. Screen:						
Metric	1.00	7.0	0.43	0.43	±0.15	±0.020
Customary	0.0394	17.8	0.0169	....	±0.4	±0.0008
0.85-mm. Screen:						
Metric	0.85	8.0	0.40	0.47	±0.2	±0.015
Customary	0.0335	20.3	0.0157	....	±0.5	±0.0006
0.71-mm. Screen:						
Metric	0.71	9.0	0.40	0.56	±0.3	±0.012
Customary	0.0280	22.9	0.0157	....	±0.75	±0.0005
0.59-mm. Screen:						
Metric	0.59	10.0	0.41	0.69	±0.4	±0.012
Customary	0.0232	25.4	0.0161	....	±1.0	±0.0005
0.5-mm. Screen:						
Metric	0.50	12.0	0.33	0.66	±0.4	±0.012
Customary	0.0197	30.5	0.0130	....	±1.0	±0.0005
0.42-mm. Screen:						
Metric	0.42	14.0	0.29	0.69	±0.6	±0.010
Customary	0.0165	35.6	0.0114	....	±1.5	±0.0004
0.36-mm. Screen:						
Metric	0.36	16.0	0.26	0.72	±0.6	±0.010
Customary	0.0142	40.6	0.0102	....	±1.5	±0.0004
0.29-mm. Screen:						
Metric	0.29	20.0	0.21	0.72	±0.8	±0.010
Customary	0.0114	50.8	0.0083	....	±2.0	±0.0004
0.25-mm. Screen:						
Metric	0.25	23.0	0.185	0.74	±1.0	±0.008
Customary	0.0098	58.4	0.0073	....	±3.0	±0.0003
0.21-mm. Screen:						
Metric	0.21	27.0	0.16	0.76	±1.0	±0.008
Customary	0.0083	68.6	0.0063	....	±3.0	±0.0003
0.17-mm. Screen:						
Metric	0.17	31.0	0.15	0.88	±1.0	±0.008
Customary	0.0067	78.7	0.0059	....	±3.0	±0.0003
0.14-mm. Screen:						
Metric	0.14	39.0	0.116	0.83	±1.0	±0.008
Customary	0.0055	99.1	0.0046	....	±3.0	±0.0003
0.125-mm. Screen:						
Metric	0.125	47.0	0.089	0.71	±1.5	±0.008
Customary	0.0049	119.4	0.0035	....	±4.0	±0.0003
0.105-mm. Screen:						
Metric	0.105	59.0	0.064	0.61	±2.0	±0.008
Customary	0.0041	149.9	0.0025	....	±5.0	±0.0003
0.088-mm. Screen:						
Metric	0.088	67.0	0.061	0.69	±2.5	±0.005
Customary	0.0035	170.2	0.0024	....	±6.0	±0.0002
0.074-mm. Screen:						
Metric	0.074	79.0	0.053	0.72	±3.0	±0.005
Customary	0.0029	200.7	0.0021	....	±8.0	±0.0002
0.062-mm. Screen:						
Metric	0.062	98.0	0.040	0.65	±3.5	±0.005
Customary	0.0024	248.9	0.0016	....	±9.0	±0.0002
0.052-mm. Screen:						
Metric	0.052	110.0	0.039	0.72	±4.0	±0.004
Customary	0.0021	279.4	0.0015	....	±10.0	±0.00015
0.044-mm. Screen:						
Metric	0.044	127.0	0.035	0.80	±5.0	±0.004
Customary	0.0017	323.0	0.0014	....	±12.0	±0.00015

*An abstract of a paper to be presented at the meeting of the American Institute of Mining Engineers to be held at St. Louis, October, 1917.

ly different mesh and wire diameter than that called for in the screen scale, provided the resultant opening is the same as the nominal opening within a small range. This will make possible the use of a number of screens now on the market until manufacturers of screens can furnish them made more exactly in accordance with the specifications.

The Bureau of Standards announces that it will test screens of this series to determine whether they conform to specifications given below. This test will consist of the examination of the mesh of both the warp and shoot wires of the cloth to ascertain whether it comes within the tolerances allowed; also measurements of the diameter of wires in each direction to determine the average diameter, and a measurement of any large openings to ascertain whether they exceed the limits given in these specifications; also an examination of the screen to discover any imperfections that may seriously affect its screening value. Screens that pass the specifications will be stamped with the seal of this bureau and will be given an identification number. A certificate will be furnished for each screen that passes the requirements. For screens that fail to meet the specifications, reports will be rendered showing wherein the screen was not up to the standard.

A fee of $2 each will be charged for the test of the screens when submitted singly. For from two to nine screens submitted at one time the fee will be $1.50 each. For lots of 10 or more the fee will be $1 per screen. Only half of the fees mentioned will be charged for such screens as may be rejected for exceeding the tolerances of mesh, in which case the wire diameter will not be measured.

Specifications for Standard Screens

Wire cloth for standard screens shall be woven (not twilled, except that the cloth of 0.062-mm., the 0.052-mm. and the 0.044-mm. screen may be twilled until further notice) from brass, bronze or other suitable wire and mounted on the frames without distortion. To prevent the material being screened from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder or so made that the material will not catch.

The number of wires per centimeter of the cloth of any given screen of the standard screen scale shall be that shown in the accompanying table, in the second column, headed "Mesh," and the number of wires in any whole centimeter shall not differ from this amount by more than the tolerance given in the fifth column, that headed "Mesh" under the heading "Tolerances." No opening between adjacent parallel wires shall be greater than the nominal width of opening for that screen by more than the following amounts: 10% of the nominal width of opening for the 8-mm. to 1-mm. screen, inclusive; 25% of the nominal width of opening for the 0.85-mm. to the 0.29-mm. screen, inclusive; 40% of the nominal width of opening for the 0.25-mm. to the 0.125-mm. screen, inclusive; 60% of the nominal width of opening for the 0.105-mm. to the 0.044-mm. screen, inclusive.

The diameter of the wires of the cloth of any given screen shall be that shown in the third column of the table, headed "Wire Diam." and the average diameter of the wires in either direction shall not differ from the specified diameter by more than the tolerance given in the last column, under "Tolerances" headed "Diam."

The Bureau of Standards also reserves the right to reject screens for obvious imperfections in the screen cloth or its mounting, as, for example, punctured, loose or wavy cloth, imperfections in soldering, etc.

Until further notice, to permit the use of screens now on the market which have slightly different mesh and wire diameters from that specified, screens will be certified as satisfactory if the measurements of mesh and wire diameters show the resulting average width of opening to be within 4% of the nominal opening of a given screen, and the ratio of wire diameter to opening of the screen in question is within 0.03 of that given in the table in the column headed "Ratio Wire Diam. to Opening" for the 8-mm. to the 2-mm. screens, inclusive, and within 0.06 of the ratio given for screens of smaller openings than 2 millimeters.

Chronology of Mining for June, 1917

June 4—Miners resume work in Jerome, Ariz., after 10-day strike; union not recognized.

June 7—First electrolytic copper produced by New Cornelia Copper Co.'s leaching plant, Ajo, Ariz.—Announcement of increase in authorized capital stock of American Metal Co. from $3,500,000 to $25,000,000, though immediate actual increase will only be to $7,000,000.

June 8—Fire in Granite Mountain mine of North Butte Mining Co., Butte, Mont., resulted in death of 164 men.

June 11—Beginning of I. W. W. strike at Butte, Mont., curtailing work to day shift for the most part with 10 to 25% of the normal crews—American Smelting and Refining Co. resumed operation of two copper furnaces at Aguascalientes, Mexico.

June 12—U. S. Steel Corporation and many other mining and metallurgical companies declared special dividends, recommending that stockholders endorse checks over to the American Red Cross.

June 13—Strike at Tooele, Utah, smeltery of International Smelting Co.; voted to return to work on June 30.

June 20—Roasting furnaces started at Bunker Hill & Sullivan lead works, Kellogg, Idaho.

June 21—Greene-Cananea copper operations in Sonora, Mex., closed down as result of interference by government officials, American employees returning to the States.

June 22—Canadian government took over operation of Crow's Nest Pass coal mines where strike had been in force for several months resulting in closing of Granby's Grand Forks, B. C., copper smeltery and restriction of other metal production.

June 26—I. W. W. union at Bisbee, Ariz., started strike, about 50% of the miners stopping work.

June 27—United States Government placed order for 60,000,000 lb. of copper at 25c. per lb.

South African Metal Production in 1916 was as follows, according to "Chem. Trade Journ.," May 12, 1917: Copper, 22,861 short tons, compared with 28,970 tons in 1915; tin, 3263 tons, compared with 3441 tons in 1915; silver, 968,904 ounces.

Events and Economics of the War

During the week Russia has shown that she still must be reckoned with. Her offensive continues. The German demand for electoral reform, whether granted or not, is an ill-omen for Prussian autocracy. London has borne another raid of little military value. Other than these, few things abroad draw attention.

In the United States, the importance of checking spies is receiving greater attention. The prohibition enactment, which had the limelight in the Senate, proved a fiasco. Action by the President to secure early passage of a food bill is expected.

Americans May Work Russia's Mines

A cablegram from Petrograd announces that the Mining Commission of the Russian Ministry of Trade decided recently to recommend the transfer of a great part of the empire's mines and other mineral deposits to American hands. The commission has decided to speed up its proceedings in order to reach a decision during the stay of Elihu Root, head of the American mission, and also in view of the impending departure to America of Russian mining experts who will join the party of Ambassador Bakhmetieff. M. Maliavkin, director of the Mining Department, propounded a scheme to the commission to offer American capitalists the Island of Sakhalien, off the eastern coast of Siberia, for working petroleum and coal deposits, and also to offer for the same purposes several districts of Siberia. He also recommended the transfer to American hands of the gold mines in the Altai Mountains, the copper mines in the Caucasus and the railroads in the Ural Mountains.

It is assumed from this dispatch that it is the intention of the Russian government to invite American capital to undertake the development of latent mineral resources of Russia, and that the restrictions and bureaucratic red tape that formerly discouraged investment in these fields are to be removed.

To Establish Aircraft Exhibit

The National Advisory Committee for Aëronautics and the Aircraft Production Board of the Council of National Defense have instituted a project for a permanent exhibit of aircraft materials of all kinds, including engine parts and sections of planes, to be established in Washington for the benefit of army and navy engineers and American manufacturers. A building to house the exhibit is now being constructed by the Government south of the Smithsonian Institution, and the display will be made available to all aircraft manufacturers and kept up to date as the science develops. It is expected to be of material assistance to the new aircraft-building project in that it will enable American manufacturers to become familiar with the latest developments in the art.

The latest foreign machines and specialized parts from foreign makers, reflecting the highest development of European building science after the three years of war, will be displayed. The exhibit promises to be of particular value in the near future in enabling Government engineers and private manufacturers to study the designs and details of construction with a view to learning to what particular branch of the industry manufacturing plants can best be adapted in the creation of the new American air fleet.

"The Aircraft Production Board has no illusions as to the size and character of the job before it," a statement issued by the board says, "but the whole task is one of industrial organization for quantity production, and in this we Americans are above all other nations fitted by experience and tradition to break records. The new permanent aircraft exhibit should furnish a valuable aid to the process of familiarizing the industry with the task and organizing for its accomplishment."

Laboratory for Aëronautic Research

The National Advisory Committee for Aëronautics has just closed a contract with the J. G. White Engineering Corporation for the erection of a research laboratory on Langley Field, near Hampton, Va. At this laboratory, in addition to the usual structural tests on airplanes and airplane parts, scientific research peculiar to aëronautics will be conducted under the immediate supervision of the committee.

Instruments are now designed for use on airplanes to measure the various quantities that enter into the performance of a plane when in free flight. In particular these measurements will include the thrust developed by the propeller, the power absorbed and the revolutions, also the various movements made by the control levers and the resulting motions of the plane, including rolling, yawing, pitching, and likewise the attitude of the plane as a whole in relation to the horizontal.

A wind tunnel of the Eiffel type will be erected for model tests on air planes, surfaces and propellers. Having the results of tests on models and full-sized surfaces, it will be possible to determine more accurately the laws by means of which results from model tests may be applied to full-sized machines and surfaces.

Survey Engineers Assigned to Military Duty

Forty-five engineers of the Topographic Branch of the Geological Survey, who are members of the Engineer Officers' Reserve Corps, have been assigned to active duty and ordered to report by letter to the Director of the Survey, at Washington, for duty in connection with military mapping now being done for the War Department.

Among the men affected are Majors Frank Sutton, William H. Herron, Robert B. Marshall, Glenn S. Smith, George T. Hawkins, Robert Muldrow, James H. Jennings, William H. Griffin, Robert H. Chapman, Joseph

H. Wheat and Albert M. Walker; Captains Claude H. Birdseye, Emory I. Ireland, Clyde B. Kendall, Albert Pike, Herbert H. Hodgeson, Carl L. Sadler, J. G. Staack, William L. Miller, Eugene L. McNair, Asahel B. Searle, William O. Tufts, Bertram A. Jenkins, James W. Bagley and Calvin E. Giffin. The list also includes 20 first and second lieutenants.

Price of Soft Coal Lowered

As a result of the conference between the mine operators, the Secretary of the Interior, Federal Trade Commissioner Fort, Chairman Peabody and the Committee on Coal Production of the Council of National Defense, the following reductions were made to go into effect July 1 in the prices of coal. In the various coal fields east of the Mississippi, a maximum price was set, pending further investigation, ranging, with one or two exceptions, from $3 to $3.50 per ton of 2000 lb. aboard the cars at the mine.

This, according to the Director of the Geological Survey, will effect a reduction to the consumers east of the Mississippi River of $15,000,000 a month, based on the output of free coal in May of this year. These prices do not affect in any way contracts in existence or sales of coal for foreign or export trade.

The operators tendered to the Government a reduction from these reduced prices of 50c. per ton for coal that the Government may need. No action was taken upon anthracite prices because of the fact that these prices had already been acted upon by the Federal Trade Commission. Twenty-five cents per net ton was fixed as the maximum price for coal jobbers' commission, with only one commission, no matter how many jobbers' hands the coal may pass through.

On account of an inadequate representation of operators west of the Mississippi River, no maximum prices were fixed for coal from those districts. A supplementary statement will be issued shortly, covering prices on coal produced in those districts. The operators present at the conference included seven for each coal-producing state.

Fortunes of War

The Germans were prodigal in their use of iron, says the New York *Sun*, when they constructed their defenses along the old line that fell before the rush on July 1, 1916. They intended to stay there for the remainder of the war and then recover the material they had used in construction. When the British bombardment began, with its previously unknown force of destruction, the iron and steel collapsed or was pounded to flinders. Taking any direction from Bapaume, one may walk for hours over fields that are gold mines for salvage parties. If the barbed wire alone could be bought up by one company, its directors could retire for life on the profits. Hundreds of thousands of miles of wire remains intact, some of it still unrusted.

Standing on the summit of the Butte de Warlencourt, one may look for miles over a territory every square foot of which is covered with iron, steel, old boots, rags, caps, bottles and tools of every description. Shell holes are filled with débris of this nature, and clear to the very horizon the ground is pitted with these holes. As the war progresses, the waste of material undoubtedly will be greatly decreased through organizations, but over this area the junkman and the salvage party will reign supreme for years to come.

Wood for Next Winter

The Department of Agriculture authorizes the following: To meet any possible coal shortage in the West next winter, more extensive use of fuel wood from the national forests is urged by the Government foresters, who are advising both ranchers and town dwellers to be forehanded in making arrangements for the supply of their fuel needs.

The supervisors of the 153 national forests will be instructed to afford all possible facilities to local residents wishing to obtain cordwood, which settlers may secure free for their home use and which is sold at low rates to persons cutting and hauling in order to sell to others.

Since the material thus utilized is mainly dead timber, its removal, it is explained, helps clear up the forest and thus lessens the fire menace. Timber that is insect-infested or old and deteriorating, or otherwise damaged or undesirable from the forester's standpoint, is also disposed of for fuel purposes. The demand in the next 12 months is expected to break all records.

There is a possibility of a coal shortage because of the increased demand for coal by industrial plants and the lack of sufficient means of transportation. It is believed that it will be quite feasible and economical for many Western communitites to utilize an increased quantity of national-forest wood for fuel next winter.

Survey to Issue Geographical Handbooks

The geography committee of the National Research Council decided to secure if possible the preparation and publication of a series of handbooks on the geography of the military divisions of the United States, in which a compact statement of their physical features, leading industries, transportation lines, etc., should be presented in form for ready consultation or study by army officers and others.

The plan gained the approval of the council and of the Army War College and was submitted to the Director of the United States Geological Survey, who undertook to have the handbooks prepared by members of the survey in coöperation with the geography committee. They will be published as bulletins of the Survey.

The Remedy for High Prices

In its July circular the National City Bank in discussing high prices among other things says: "High prices are never welcome to those who have to pay them, but it is a great mistake to consider only their immediate and uncomfortable effects without regard to the conditions that caused them or the part that high prices play in correcting those conditions. High prices are a sign of scarcity. The only real remedy for scarcity is increased production, and no other agency is so directly effective in stimulating production as high prices. They not only create an inducement, but they supply the capital for the effort."

Editorials

The Controversy Over Prices

THE controversy over the prices for commodities that has been going on in Washington ever since the United States entered the war is crystallizing. Already a split in the Cabinet is threatened and inevitably there will be the appeal to Cæsar that a fortnight ago we forecasted. In the opinion of many officials the question may involve the entire makeup of the Council of National Defence and its subordinate civilian committees of business men.

One element, said to include most of the membership of the defence council's committees, is for a purchasing policy that will allow liberal profits to producers to stimulate production. These officials declare the Government will obtain far better service if the Government does not try to drive its bargains to hard. This is the view of the business men and of the economists, and apparently is supported by Secretary Lane, the strong man of the Cabinet.

Other officials, led by Secretaries Daniels and Baker, believe the Government should bring every pressure to bear to obtain the lowest possible prices, and some, it is said, are for commandeering supplies. This is the view of the inexperienced theorists, the politicians catering to populistic and socialistic dreamers, who see in every business man the physiognomy of the plunderer and crook.

There is a third and even more alarming view, more alarming owing to its nonsensical vagary. The Federal Trade Commission, which is investigating production and manufacturing costs on basic materials, takes the position that any prices agreed between the Government and producers or fixed under a power to commandeer should go to the general public as well. If the Government goes into the market for large purchases at low prices, it is pointed out, the private consumer will be forced to pay even higher prices than he now pays because producers under no sort of restraint will raise their prices to him to make up for their loss in selling to the Government. Some members of the commission are for legislation to meet the difficulty.

The Federal Trade Commission is correct in its view that if the Government exacts low prices for itself the private consumer will have to pay even higher prices. That is certain. Already has it happened. However, it will not be by producers raising their prices, but by consumers bidding for the curtailed supplies.

But if the views of the Federal Trade Commission should prevail, if the Government should fix low prices for everybody, who is going to attend to the distribution? If, for example, the Government has fixed the price for aluminum at 25c. per lb., if consumers would like to buy twenty million pounds per month at that price but the supply is only ten million, what authority is going to say who shall have it and who shall not?

Suppose the Government itself needed ten million pounds of a commodity, had fixed a price for it at cost plus 10%, and the total supply was but half the amount required? Who is going to furnish the capital to build the plants to produce what is needed?

These questions are not stretching of the imagination. Great Britain had to answer them and analogues of their principles are running through all business today.

If business organization were so simple as Mr. Daniels and Mr. Baker believe, innocently but ignorantly, we might defer to their vanity, or sharp practice, and sell them commodities at less than the market price, making it up from the other customers, just as the greengrocer compensates for his bad accounts. The paying customers would suffer, but the natural law would compel them to pay the penalty for bad business methods. If big business were so simple as this, we say, producers could afford to be indifferent to what Mr. Daniels and Mr. Baker want to do. But unfortunately it is not so simple, and the disturbance that is created plays the mischief to everybody.

Consider, for example, a recent transaction in copper. The Government bought 60,000,000 lb. at 25c., the market price at that time being about 30c. The chairman of the copper committee asks the producers to contribute pro rata to the Government contract. What happens? The small producers—those who sell their ore to smelters, whose output is individually small, but in the aggregate is considerable—can not conveniently be reached and escape their quota, which causes the larger producers to supply more than their share. The refiners who buy copper material on average price contracts, and this represents a large proportion of the total business, can not contribute, for they can not buy copper at 30c. and sell it for 25c. and long remain solvent. Many of these contracts are with foreign producers, including British. If the ideas that prevail in Washington are carried out, that is, not only buying cheaply for this Government but also for our Allies, we are likely to witness this condition, namely: (1) The subtraction from the market of a large quantity of copper at a relatively low price. (2) Further rise in the free market, owing to that subtraction. (3) Payment by American refiners to British producers at the high market prices, according to the contracts with them. (4) Dear copper to American consumers. (5) American producers supplying cheap copper to the British Government and British consumers. (6) American Government losing taxes on excess profits. This would be rank stupidity.

The wiseacres of the Federal Trade Commission apparently have some glimmerings of ideas as to how things would work, so they propose to limit prices to everybody. In other words they would put a blight

upon production. If there is one sure formula for losing the war they have got it.

Not only would their project discourage production in this country, but also would it result in a large decrease in the importation of raw copper into this country, which importations constitute a large part of the supply of our refiners. If the price paid for copper abroad were around 30c., and if sellers in the United States were forced to give away copper at a lower price, it would be but natural that the blister copper now coming to this country from South America, South Africa and elsewhere would first be held back and later, when adequate refining facilities had been established in Europe, would find its way thither.

This whole matter of price fixing, commandeering, etc., has received something of a shock with respect to the foolish whisky amendment that the Senate tacked on to the food bill. According to this the President was directed to commandeer all distilled spirits in the bonded warehouses of the United States; and, after paying to owners thereof the cost of production, plus 10%, redistill this liquor for the production of alcohol for Government use.

The same Senators who voted for this on Saturday admitted on Monday that the project is in direct violation of Article V of the Constitution of the United States, which says: ". . . nor shall private property be taken for public use without just compensation." "In fixing the price at which whisky in bond is to be taken over by the President," said Senator Shields, "this bill has become involved in a judicial complication. The Senate has undertaken to arrogate to itself power that belongs to the courts. Congress may legislate power to commandeer, but when it attempts to fix prices, it encroaches upon the authority of the judiciary. How can Congress say what is to be a fair price for property to be taken over unless there has been an exhaustive inquiry into it? To say that cost plus 10% is a fair price for this whisky is to hit arbitrarily upon a price without any real attempt to arrive at a fair calculation. Manifestly, if any price is to be fixed by Congress, it ought to be the market price and not the cost of production plus something."

It looks as if what would be unconstitutional with respect to whisky would be also unconstitutional in the cases of steel, coal, copper, etc. It looks, moreover, that when Secretary Daniels and Secretary Baker have been obtaining supplies by fair trading with the producers, they have been correct, but when commandeering at prices fixed arbitrarily by themselves they have been acting unconstitutionally.

Moyer versus Haywood

ONCE the pot called the kettle black. Pres. Charles H. Moyer, of the International Union of Mine, Mill and Smelter Workers, is credited with the following remarks about that horrid child of the I. W. W., the Metal Mine Workers Industrial Union, which is now interfering, by strikes, with the copper production of the West: He charges the I. W. W. with "participation in a nation-wide conspiracy to shut down the copper mines of the country. There is no doubt the I. W. W. are trying to put us (the International Union) in a bad light with the Arizona operators. If there should be any violence in Arizona, I lay it at the door of the I. W. W." To mining operators who know his past history, it is interesting to see President Moyer, of the International Union of Mine, Mill and Smelter Workers, posing as an apostle of peace and gentleness.

Only about three years ago Moyer's organization, then known as the Western Federation of Miners, had acquired such a reputation for violence that mining operators would no longer deal with it. Its record of murder and incendiarism had practically wrecked it. It had alienated the active support of the better class of miners, lost all its important strikes and the sympathy of the outside public in the mining communities. Its name meant only strikes, violence, loss of wages and of business. It had passed the zenith of its power through violence. But President Moyer had a vision. The Western Federation was taboo, but who would know it if it were called "International?" The violent Western Federation went into the chrysalis, and by a change of name we are now to understand that it has evolved into a beautifully painted moth of peaceful and model unionism.

After a few sonorous platitudes over the irregularity and destructiveness of the I. W. W. *enfant terrible*, President Moyer expects that mining operators will welcome the opportunity to sign up with the International. Thus might the metal-strike situation be cleared up—to the great advantage of the Western Federation's new child. And President Moyer would have outwitted his old-time associate, W. D. Haywood, now head of the I. W. W., and would also have paid back that old score in Butte where the I. W. W. succeeded in routing the Western Federation's local, dynamiting its hall and requiring the militia to restore order in the internecine fight. Which gets us back to an old question, "Can the leopard change his spots?"

This Milling Number

THIS special number of the *Journal*, devoted especially to the interests of mill-men, is the second of the series, the first having been published just about a year ago. Since that first publication, important things have happened in the practice of ore milling, and we are able therefore to report some exceptionally interesting things in this issue.

Most noteworthy, perhaps, is the successful development of the ammonia leaching process by the Calumet & Hecla company, which is thoroughly described by Mr. Benedict, metallurgist of the company. We feel sure that his article, so excellently presented, will be regarded as one of the most important contributions of the year. Ammonia leaching, both for copper and zinc, has long been a subject of experimentation, but it remained for Mr. Benedict to make it a metallurgical

process of application in practice on a large scale. The Calumet & Hecla company is doing other interesting things, such as the oil flotation of finely divided native copper contained in slimes, of which it looks as if we are destined to hear successful things later.

The flotation process receives much attention in this issue, in view of its great importance in the art. The contributions of Mr. Coghill, Mr. Adams and Mr. Kirtley are all illuminating and valuable. The other articles, touching upon such questions as mill lighting, ore crushing, drum filters and general milling practice, are all by competent authorities and are of the kind of article that our milling readers like to have.

The Flotation Litigation

WE CONFESS to feelings of impatience and vexation that the litigation over the flotation patents is so long drawn out that it looks interminable. Court after court decides, even the highest court, and it is hoped that there will be a pronouncement that will settle all things. But it turns out there is only settlement of some things and there is always left some foothold for fresh litigation. Is not there reasonably an irritation that the respective litigants, with their costly lawyers and experts, cannot present this case in such a way as will permit a final adjudication by the courts?

In our last comments on this subject, following the Philadelphia decision, we made the remark, based upon an abstract of the decision, that it seemed to "nail Callow." After reading the full text of the decision, it appears that that may not be so and that there is indeed ground for the further litigation, which is promised.

In order to get a correct idea of how things stand, we must go back to the decision of the United States Supreme Court, Dec. 11, 1916, in the case of Mineral Separation vs. Hyde. That high court dwelt especially upon the essence of the invention being in the use of an amount of oil that is "critical," in fact, less than 1% figured with respect to the ore. Together with the use of oil within that limitation, was the impregnation, by agitation, of the mass of ore, oil and water. The court said:

> The process of the patent in suit, as described and practiced, consists in the use of an amount of oil which is "critical," and minute as compared with the amount used in prior processes "amounting to a fraction of 1% on the ore," and in so impregnating with air the mass of ore and water used, by agitation—"by beating the air in the mass"—as to cause to rise to the surface of the mass, or pulp, a froth, peculiarly coherent and persistent in character.

In rendering its decision, the court said:

> The patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as "critical proportions" amounting to a fraction of 1% on the ore.

We have published in the *Journal* the full text of the majority opinion of the United States Circuit Court of Appeals for the Third Circuit in the case of Minerals Separation vs. Miami Copper Co., which for convenience is referred to as the Philadelphia decision. In that decision, and in the arguments preceding it, there is apparently a wide difference in the interpretation placed by the contestants and by the court upon decisions previously rendered. This resolves itself essentially into the question of how the mass of ore, oil and water be impregnated with air.

The defendant in the Philadelphia case maintained that the Supreme Court interpreted the patent and limited its scope through the introduction "by beating the air" into mass. The patent, however, does not use the words that are quoted, and the Philadelphia court did not think that these words, as used by the Supreme Court in describing the process, could be construed as a limitation upon the process. The defendant, moreover, maintained that the Supreme Court limited the patent to agitation by mechanical means, thereby excluding pneumatic means, but the Philadelphia court did not agree with that contention. Furthermore, the defendant argued that in the use of the Callow cell alone there was no agitation, the air introduced through the bottom simply rising to the surface in short-lived evanescent metal-bearing bubbles forming a "foam."

The Philadelphia court held that in practices at Miami where the ore was handled by centrifugal pumps and Pachuca tanks, as well as by Callow cells, there was mechanical agitation, and consequently infringement of the Minerals Separation patent that had previously been upheld by the Supreme Court.

The Philadelphia court said, however, that it is true that in the use of the Callow cell the behavior of the froth is different from what it is when agitation is practiced. Also, that it is true that in the Callow cell aëration is direct and is not the result of or caused by agitation. The court said, further: "The operation in the Callow cell certainly possesses these distinguishing features from operation of the process where aëration is caused by agitation."

The Philadelphia court then became distinctly muddled. The defendant in the case urged that the operation of the Callow cell was not dependent upon the precedent treatment of pulp in the Pachuca tank and that the same results could be obtained from the Callow cell without such previous agitation and aëration. The court said that it found "nothing in the evidence or in the demonstrations which justified that argument," but admitted that

> If the only agitation to which the pulp was subjected (after such agitation as in the prior art was necessary to mix the oil and ore) was the agitation of the Callow cells, we would not say that that agitation amounted to or was the equivalent of the violent agitation of the patent disclosure and constituted infringement.

Subsequently, there came the statement of an officer of the Miami Copper Co., which was published in the *Journal* a few weeks ago, to the effect that the centrifugal pump, the break in the circuit and the Pachuca-tank agitation have not constituted a part of the process used by his company for some time back; and that the company does not now infringe, inasmuch as the Callow cell, unless preceded by agitation greater than that of the prior art, is not an infringement. This contention is apparently quite in line with what was said in the Philadelphia decision. It is unfortunate that this im-

portant point was not brought out in the trial of the case. Clearly, there must be further litigation to settle the status of the Callow cell and the principle involved in it, which is apparently exempted by the Philadelphia decision, while on this point the Supreme Court decision is doubtful.

Besides this point there is the new contention of Minerals Separation that the decision of the Supreme Court as to less than 1% of oil is not limiting. Altogether there is still confusion, which must be dispelled before the situation will become clarified.

Metallurgical Mills of United States

ACCORDING to a careful compilation of plants listed in the various volumes of "Mineral Resources" up to the year 1912, in that year there were in existence 1592 plants with an aggregate daily capacity of 182,116 tons, or an annual capacity of 54,635,000 tons. These figures did not include any plants operated in connection with the iron-ore industry, or any in the central belt of the states from Michigan to Arkansas, or in the East.

A compilation of the Michigan copper concentrators made from the "Copper Handbook," 1913, gives 19 mills having 69 stamp heads then operating with an aggregate daily capacity of 55,350 tons, or an annual capacity of 16,500,000 tons.

According to the publication of the Missouri Bureau of Mines, in the year 1914 there were then operating within the state 135 mills having an aggregate daily capacity of 44,750 tons, or about 13,425,000 tons annually. The milling capacity of 65 plants in the Wisconsin-Illinois zinc-lead district as compiled by the *Journal's* correspondent is 7130 tons daily of 20% ore, or about 25% greater for 10% ore or, say, 8900 tons. His estimate is in error regarding the capacity of the Mineral Point Zinc Co. as shown by that company's own report to the *Journal*. The correction is about 215 tons daily to be added to the above figures, bringing the total to, say, 9100 tons daily, or 2,730,000 tons annually.

From the *Journal's* annual reports on new construction from 1913 to 1915 inclusive is compiled a list of 231 new mills having an aggregate daily capacity of 56,300 tons, or 16,890,000 tons annually.

Adding the totals enumerated gives a total of 2042 plants having an annual milling capacity of 104,180,000 tons. This does not include iron-ore plants or other metallurgical plants in states of the Atlantic Coast group. Reports from 50 of the largest iron-mining companies show that 10 of them mill annually 4,717,000 tons, so that the total iron milled probably at least approximates 5,000,000 tons.

With no allowance made for destruction by fire and other causes since 1912, we shall not be far wrong in stating that up to the beginning of 1916 there were 2052 mills in existence having an annual capacity of nearly 110,000,000 tons of ore. Exactly how many of these mills are active at present, it is of course impossible to state, but probably a very large proportion operated during 1916.

In the *Journal's* attempt to get an idea of the capacity of those active, 230 requests for information were sent out to the largest companies, which produce about 75% of the total output, of which 170, or about 74% of the total, replied. The replies of these 170 probably represent 60% of the total mineral output of the country. Of the 170 companies replying, 110 operate mills having an aggregate milling capacity of 63,188,695 tons annually, as shown in the following tabulation:

	Type of Mines	Number Reporting	Annual Capacity
1.	Gold and silver	46	9,368,225
2.	Copper	30	39,010,500
3.	Lead and zinc	24	10,093,150
4.	Iron mines	10	4,716,820
		110	63,188,695

These figures, imperfect as they are, give some idea of the magnitude of the ore-milling industry of the United States. Probably 50% of all the ore mined in the United States has to pass through a mill. If we exclude iron ore, the proportion is much higher.

Coarse and Fine Crushing of Ores

THE brief article in this issue by David Cole, wherein he describes the recently constructed plant of the New Cornelia company, is full of meat. The chief regret of our readers will be that Mr. Cole did not enlarge upon his interesting subject. Technical literature is incalculably enriched by the contributions of such experts as he.

The coarse-crushing plant was Mr. Greenway's idea and was splendily worked out by Mr. McGregor, as was also the storage bin, which is out of the usual, being a square floor of concrete 90 x 96 ft., standing upon 130 reinforced-concrete posts 10 ft. high and provided with side-boards of looped steel to confine the toe of the pile, so to speak, on the four sides. At Ajo it is referred to as being a reminder of the original University on the Nile.

The fine-crushing plant and the redesign of the crushing units were Mr. Cole's own work. They have proved good as far as they have gone. It is prophesied that the remodeled Symons disk crusher of vertical type will take the place of the horizontal type, and when better known will largely replace rolls for dry crushing, and especially for granulating work.

Mr. Burch was the pioneer in visualizing the possibilities of the fine-reduction disk. If his problem at Inspiration had not worked out best with Marcy mills, he would doubtless have done the remodeling necessary to make the disk crusher reliable and good. It fell to the lot of Mr. Cole to do that, and it is pleasing to report the success that seems to be following his work.

We receive a certain number of anonymous letters. These are more generally of approving character than critical. We should like to make use of some of them, but we cannot break our rule that we do not pay attention to anonymous letters. We do not see why any of our friends should omit to sign communications of this sort. Signature is, of course, simply an evidence of good faith, and not necessarily for publication.

Personals

H. H. Knox has recently returned to New York from a trip to Mexico.

John M. Fox has returned to Tonopah, Nev., to make his headquarters there.

W. E. Eells, of the Cia. Metalurgica Mexicana, will leave for the south next week.

W. F. Hansbrouck, of the Anaconda Copper Mining Co., was a recent visitor at Ajo, Ariz.

Frederic de P. Hone & Co., engineers, announce the removal of their New York office to 13-21 Park Row.

Herbert C. Hoover, on July 4, was created a Commander of the Legion of Honor by the French Government.

W. H. Bennett, W. J. Wheelen and Howard Moore, formerly of Morococha, Peru, have recently joined the staff of the Andes Exploration Co., at Arequipa.

M. K. Rodgers was reported in the issue of June 30 as having died in Pittsburgh. This was an error. Mr. Rodgers has been seriously ill but is said to be improving slowly.

Henry G. Smith, superintendent of the La Luz mine in Nicaragua, recently arrived in Bluefields on his way back to the mine, after a three months' vacation in the United States.

Sumner S. Smith is at the Eska Creek coal mine, Anchorage, Alaska, acting as resident engineer in charge of the opening of the coal mines in the Matanuska coal field for the Government.

J. S. Stewart, superintendent of the Pickands Mather Co.'s mines on the eastern end of the Mesabi range for the last six years, has resigned. He is succeeded by D. Cavin, of McKinley, Minn.

L. D. Ricketts left on July 5 for Warren, Arizona, to take three months' complete rest. His health is very much improved, but it will probably be a long time before he fully regains his strength.

Jay A. Carpenter has resigned as general superintendent of the Nevada Packard Mines Co., at Rochester, Nev. No successor is to be appointed as the president of the company is taking personal charge.

H. Marten, chief engineer for the Oliver Iron Mining Co., at Hibbing, Minn., has been appointed district engineer for the same company at Virginia, Minn. L. L. Davenport has been made chief engineer.

Edwin S. Boalich has resigned his position with the Bureau of Mines to go on the engineering staff of Fletcher Hamilton, state mineralogist of California. B. O. Pickard has been appointed to the vacancy.

S. C. Dickinson, who was in charge of the demonstration work of the United States Bureau of Mines at the exposition in San Francisco, has been appointed safety engineer for the Arizona State Bureau of Mines.

H. Robinson Plate has gone to California as representative of a company that has taken an option on the Sheep Ranch mine on the Mother Lode. His address will be Sheep Ranch, Calaveras County, Calif.

N. H. Emmons, 2d., formerly general manager of the Tennessee Copper Co., has returned to Boston, after several months' work developing a bauxite mine in Georgia. His Boston office is Room 350, John Hancock Building.

H. C. Ryding has been chosen vice-president of the Tennessee Coal, Iron and Railroad Co., to succeed Frank H. Crockard, who has gone to the Nova Scotia Steel Co. C. J. Barr has been appointed general superintendent in place of Mr. Ryding.

Prof. Stafford F. Kirkpatrick, of Queens University, has been awarded the McCharles prize for the discovery of new processes for the precipitation of silver from solutions of Cobalt ores and for the separation of cobalt and nickel in solutions of Cobalt ores. The prize consists of a gold medal of the value of $200 and $800 in cash.

T. P. Draper, assistant superintendent of blast furnace and steel department of the Youngstown Sheet & Tube Co., Youngstown, Ohio, has resigned to become assistant general manager of operations of the Trumbull Steel Co. F. C. Farrell has been made assistant superintendent of the converting and blooming-mill departments; A. R. Finch is foreman of the converting mills to take the place vacated by Mr. Farrell. A. L. Smith has been named assistant superintendent of the open-hearth departments. H. S. Braman, superintendent of blast furnace and steel department, is assisted by C. H. Elliott.

Obituary

Leo Frank Arnold of Brooklyn, N. Y., aged 35, passed away at Tucson, Ariz., June 1. He was graduated from the Michigan College of Mines in 1903 and had been with the General Development Co.

W. Scott McCombs, veteran blast-furnace manager of the Mahoning Valley, died recently at his home in Youngstown, Ohio, after prolonged illness, aged 78 years. In the late sixties he became manager of the Struthers, Ohio, blast furnace, where he remained 10 years, and for the following 27 years he was superintendent of the Lowellville, Ohio, stack.

Societies

International Association of Industrial Accident Boards and Commissions will hold its fourth annual convention at Boston during the third week in August, 1917.

Mining and Metallurgical Society, New York Section, will hold a meeting at the Engineer's Club, 32 W. 40th St., on Wednesday, July 18, at 8 p.m., preceded by an informal dinner at 6:30 p.m.

American Electro-Chemical Society will hold its 32nd general meeting in Pittsburgh, Oct. 3-6. Delegates are invited to arrive on Oct. 2, to get together informally. A symposium on "Electro-Chemical War Supplies" will be held the morning of Oct. 4. Special entertainment features have been provided.

American Association of Engineers has tested, for two years, the rendering of service to technical engineers through its department known as the Service Clearing House. The association now proposes to broaden the scope of activity by offering to put business men and men in public office in touch with competent consulting engineers to carry out any work of an engineering nature. Frequently municipalities desire such information, but are at loss as to where they may get in touch with men in whom they may have full confidence. If given publicity, the Association believes that it can render a great service both to the public as well as to consulting engineers. A record of engineers and their work is kept through which employers may find men who, in their opinion, possess desirable qualifications. The average number of men placed in touch with vacancies has approximated 100 per month during the last two years. For this service no commission was charged, the membership dues defraying all expenses.

United Engineering Society's Engineering Council held its first meeting on June 27, in the rooms of the American Society of Mechanical Engineers. The following officers were elected: President, I. N. Hollis; vice presidents, H. W. Buck and George F. Swain; secretary, Calvert Townley; executive committee, the four officers named together with J. Parke Channing and D. S. Jacobus. Ways and means were discussed by which the founder societies through the Council may be of use to the nation. A resolution was adopted instructing the executive committee to coöperate with the Government in procuring the services of engineers. A committee of three consisting of H. W. Buck, A. M. Greene, Jr., and Edmund B. Kirby, was appointed to consider the best means of utilizing the inventive ability of members of the founder societies. The Council has recently come into being as a medium of coöperation between the four national engineering societies. Its function is to speak authoritatively for all member societies on all public questions of a common interest or concern to engineers. The council is composed of 24 members, 5 being appointed by each of the 4 founder societies and 4 by the United Engineering Society.

Industrial News

The General Electric Co. announces the removal of its New York offices from the Hudson Terminal Building, 30 Church St., to the Equitable Building, 120 Broadway.

United Zinc Smelting Corporation, together with the Pearlman Co., Inc., and the Clarksburg Zinc Co., have removed their offices from Clarksburg, W. Va., to 99 John St., New York City.

Mark R. Lamb has received orders from Bolivia for Dorr classifier equipment and for a 60-hp., double-drum electric hoist. Reasonably prompt delivery, 12 weeks, has been obtained for the hoist, in view of the present congested state of the machinery market.

Edwin G. Hatch, consulting engineer, New York, is supplying the Mother Lode Copper Mines Co. of Alaska with oil-burning boilers, steam turbine, transmission-line equipment, etc., to increase the company's copper output.

The Miami Metals Co., which is operating one of the Iroquois furnaces at Chicago on manganese alloys, has bought the Zimmerman mine at Iron River, Mich., from the Spring Valley Iron Co. The mine shipped 145,716 tons last year.

New Jersey Meter Co. is offering a new type of air meter that is said to show instantly the flow of compressed air in a pipe or hose. The "Tool-om-eter," as it is called, measures the consumption of any apparatus actuated by compressed air.

Pensacola Tar and Turpentine Co., Gull Point, Fla., producers of flotation oils, announce that commercial conditions make necessary an advance in the price of its products, in addition to extra charges for metal packages, which are becoming extraordinarily scarce.

Edison Storage Battery Supply Co. announces the appointment of D. B. Mugan as resident manager at New Orleans, La., with headquarters at 201 Baronne St. Mr. Mugan was formerly associated with the Illinois Central Railroad Co. as head of its New Orleans Electrical Department.

The Booth-Hall Co., Chicago, has been formed to build electric furnaces. Following are officers of the new company: C. H. Booth, president; Julius A. Hall, vice president; W. K. Booth, metallurgist; W. D. Walker, sales manager, F. J. Sheldon, secretary. Patents are being sought on the Booth-Hall electric furnace.

Refractories Manufacturers' Association has endowed a fellowship in the Mellon Institute of Industrial Research with a view to stimulating scientific research work in the manufacture of firebrick and clay products. The Association is made up of manufacturers of firebrick, silica, chrome and magnesite brick and has an office at 220 South Michigan Avenue, Chicago.

New Patents

United States patent specifications listed below may be obtained from "The Engineering and Mining Journal" at 25c. each. British patents are supplied at 40c. each.

Copper—Process of Recovering Copper. Frederick J. Pope and Albert William Hahn, Douglas, Ariz. (U. S. No. 1,232,080; July 3, 1917.)

Drill—Hollow-Drill Steel-Punching Machine. Thomas Davies, Jerome, Ariz. (U. S. No. 1,232,235; July 3, 1917.)

Electrolysis—Electrolytic Recovery of Metals from Their Solutions and in Apparatus Therefor. Urlyn Clifton Tainton and Malcolm Foerster Lambe Aymé, Johannesburg, Transvaal, South Africa. (U. S. No. 1,231,967; July 3, 1917.)

Electrolysis—Process for Electrolytically Precipitating Metals. George C. Westby, Ludwig, Nev., assignor to Western Process Co., a Corporation of Maine. (U. S. No. 1,231,829; July 3, 1917.)

Electrolytic Cell Structure. Henry B. Slater, Riverside, Calif. (U. S. No. 1,231,955; July 3, 1917.)

Excavating—Driving-Sheave for Steam-Shovels. Ernest E. Crane, Chicago, Ill., assignor to American Manganese Steel Co., Augusta, Me., a Corporation of Maine. (U. S. No. 1,231,856; July 3, 1917.)

Gold and Silver—Process for Extracting Gold and Silver from Ore Containing Gold, Silver and Manganese Dioxid. Martinus H. Caron, Weltevreden, Java, Dutch East Indies. (U. S. No. 1,232,216; July 3, 1917.)

Magnesium Alloy—Process for the Production of an Alloy Containing Magnesium and Serving for the Deoxydization of Cast Iron or Steel. Chemische Fabrik Griesheim, Frankfort-on-Main, Germany. (Brit. No. 100,848.)

Metal-Distillation Furnace. Edward E. Cherry, Trenton, N. J., assignor of one-half to Max Movshovitz, Trenton, N. J. (U. S. No. 1,231,239; June 26, 1917.)

Ore Dock. Edgar W. Summers, Pittsburgh, Penn. (U. S. No. 1,232,119; July 3, 1917.)

Pyrometer—Variation-Pyrometer. Charles B. Thwing, Philadelphia, Penn., assignor to Thwing Instrument Co., Philadelphia, Penn., a corporation of Pennsylvania. (U. S. No. 1,232,408, July 3, 1917.)

Refractory Brick. Robert H. Youngman, Pittsburgh, Penn. (U. S. No. 1,231,684; July 3, 1917.)

Editorial Correspondence

SAN FRANCISCO—July 8

Fuel Scarcity in the towns and mining camps of Mojave desert has caused the Southern Pacific to withdraw all its old ties from sale. Recently the town of Daggett was in danger of fuel famine, but was helped out by Rand Mercantile Co., of Randsburg. The fuel problem in this region is a serious one, because of the long haul and isolation from timber lands. Coal is a luxury that costs $25 a ton in times of peace and plenty and wood is almost unknown as fuel. Crude oil is really more available than coal, but the domestic heating equipments do not include oil burners except in rare cases.

Relative Amount of Oil in proved areas of California available but in undrilled territory has been summarized in a report made to the California State Council of Defense by the State Mining Bureau, which shows that the visible supply of oil has been rapidly decreasing during the last year. A special committee, with Max Thelen of the Railroad Commission as chairman, has been engaged for several weeks investigating the oil supply used as fuel for the generating of power for railroad locomotives and many other vital industries. The report of oil in formation and undrilled is compiled from production records and well logs filed with the oil and gas department of the Mining Bureau during the last two years incidental to the protection of wells from infiltration by water and damage from improper drilling. Future use will be determined entirely by the State Council of Defense. In the week ended June 23, records show 12 new wells started, making a total of 540 since beginning of the year, 25 ready for test of water shut-off; 14 deepening or redrilling and 3 wells abandoned during the week.

Merit Rating California Mines for compensation insurance is tentatively set forth in Bull. 6, issued by the Industrial Accident Commission. The schedule was prepared by H. M. Wolfiin, state mine inspector and William Leslie, of the State Compensation Insurance Fund, assisted by Edwin Higgins, consulting mining engineer. It is submitted with a view of securing suggestions from mine owners and operators interested in order to make the schedule more applicable to the conditions obtaining in California. The schedule is presented in 10 main divisions, each of which is given the percentage rate named. (1) Safety organization, inspection, service and education, 25%; (2) safety measures, 15%; (3) falls of rock or ore, 15.1%; (4) explosives, 10.6%; (5) haulage underground, 1.7%; (6) falls of persons down chutes, raises, winzes, etc., 4.5%; (7) electricity, 0.7%; (8) miscellanous underground hazards, 10.4%; (9) shaft hazards, 9.8%; (10) surface hazards, 7.2%. These percentages have been computed from a large number of accidents in California in recent years; consideration has also been given to experience in other states where conditions are similar to California. Under the subdivisions are given brief outlines of the condition which must obtain in order that the mine in question may receive no demerits. The schedule provides for increase in rates conforming to increase in distance of medical and surgical aid from the mine, graduated from 3% for a distance of 3 miles to 30% for a distance of 30 miles. Each insurance carrier must ascertain the distance and increase its rates accordingly, and this regardless of the merit rating of the mine. In all cases the requirements of the safety rules and orders of mine safety, electrical utilization, general safety, boiler engine and air pressure, logging and sawmill, wood-working and the orders of the Industrial Accident Commission should be complied with or the risk penalized, unless exemption may be granted by the commission. After careful inspection in the field a trial merit rating was recently made at a mine where conditions are better than the average, and this is used in the tentative schedule to illustrate the method of computing the insurance rate, after deciding upon the demerits. According to the rating based upon this illustrative example the merit rate for this mine would be $5.06 per $100 of pay roll. The merit rating will not result in the rates of all mines being decreased to a point below the base rate, which is now $5.75 per $100 of pay roll. The system must be so conducted that the total amount in premiums to be paid by the mining companies will be approximately the same as without merit rating; but the companies operating under relatively dangerous conditions will pay a larger proportion of this amount. The maximum reduction that can be secured is 40%, which would make the rate $3.45 per $100 of pay roll, based on the present base rate of $5.75. On the other hand, it is stated that it is doubtful if there are any mines in California that would have to pay the maximum rate of $8.05, plus increases required by reason of their being situated more than 3 miles from medical or surgical aid. It is requested that persons interested send to H. M. Wolfiin, 525 Market St., San Francisco, all criticism on the proposed schedule, by July 15 or as soon thereafter as possible, in order that due consideration may be given such criticism or suggestion. The bulletin may be obtained without cost by applying to the same address.

BUTTE—July 7

Butte Labor Situation is still unsettled. About half the miners are at work. The situation would probably gradually clear were it not for the complications due to the mechanical unions. Representatives of the Industrial Workers of the World are here in large numbers and are working to make Butte an I. W. W. town. The Metal Mine Workers Industrial Union, while announcing no affiliation as yet, with any union is in reality believed to be a branch of the I. W. W. The action of the miners in Arizona, in going out at this time, shows that concerted action was planned. At the meeting of the Metal Mine Workers' organization, resolutions were adopted calling upon the United States Government to take over every mine in the Butte district and operate it. The miners pledged themselves if this were done to work for the Government and leave to the Government officers the settlement of wage controversies. They also demand that the rustling-card system be abolished. The miners pin their faith on Federal action because they claim the Government must have copper and zinc for munition purposes. The mining companies still stand pat in their determination not to recognize the new miners' union under any circumstances, claiming it is merely a branch of the I. W. W. national organization. Reports for June from the smelteries at Anaconda and Great Falls shows that the copper production in the first 10 days of June amounted to 10,000,000 lb. while for the last 20 days which covered the period of the strike in that month the production was 10,400,000 lb. This shows a curtailment in copper production for the month of about 50%. The mines are all running on day shift only, nearly all of them having a full shift.

DENVER—July 7

"High-grading," far from being an extinct art in the Cripple Creek district, has proved temporarily a most profitable one upon a large scale. Trials now being conducted at Cheyenne, Wyo., of a considerable number of men, arrested by Federal officials, reveal astounding facts. Aside from the confession of the ringleader that he has served eight years for wife murder, his testimony relative to trade in high-grade ore seems almost beyond belief. This man, Antonio Cuaz, has pleaded guilty. He, with Carl and Martin Muehlhausen, have become witnesses for the government. Cuez conducted a fence ("assay office") in Cripple Creek. Here he smelted ores brought to him by many confederates. The gold bullion was carried thence to Cheyenne and stored in the vaults of a liquor house for months before it was shipped to the U. S. mints at Denver, San Francisco and Philadelphia, by the Tivoli Mercantile Co. The value of the gold stolen runs well up into six figures. A flimsy statement made by one of the numerous attorneys for the defendants was that none of the rich ore from which the gold had been smelted was stolen, it coming from rich leases in which the men were interested, and the bullion was sold by devious ways and under fictitious names because the mine-owners' association hampers small producers.

SALT LAKE CITY—July 8

Leaching Plant of Utah Copper, at Garfield, is about two-thirds completed, and will probably be operating in two months with an initial capacity of 4000 tons of ore daily, which will probably be largely increased later. The plant has been in process of construction somewhat over a year, and the work has been held back by the difficulty in securing structural steel.

Tintinc Mines Information Bureau has been organized by Tintic mine operators to act as a joint employment bureau. It will have offices on Main St. in Eureka, and G. L. Davis, for many years with the Knight companies, will be in charge. Miners seeking work in the Tintic district must obtain cards from this bureau, which will be informed as to the needs of the various mining companies. With this system of issuing cards it is expected that a better class of labor will be provided; also the men seeking employment will be sent where they are needed, and considerable time will be saved in going from mine to mine seeking work.

WALLACE, IDAHO—July 7

Bonding of Flynn Group of 17 claims has caused considerable comment in the Coeur d'Alene district. This group was bonded by an Eastern company represented by D. F. Haley, consulting engineer for the Interstate-Callahan. As the dominant factor in the Interstate-Callahan is the American Metal Co., with which Mr. Haley has long been identified, it is the accepted belief that the New York company is interested.

Railroad Up Pine Creek, 10 miles in length, now seems assured. William Beaudry, manager of the Stewart Mining Co., has been notified by J. P. O'Brien, president and general manager of the Oregon-Washington R.R. and Navigation Co., that he has recommended to the executive committee of the Union Pacific system that the branch be built. This recommendation follows the report made upon the available tonnage in sight on Pine Creek by Albert Burch, mining engineer, who was employed by the railroad company to make a special investigation of the Pine Creek section. With this reasonable assurance that the railroad will be built, it is expected that the Stewart company will proceed at once with the construction of a 300-ton mill to treat the product of Denver-Nabob groups, which the company recently acquired. There are already two mills on Pine Creek, the Highland-Surprise and Constitution, each of 150 tons capacity, and it is officially announced that the Northern Light will build a mill this summer. In addition to these the Anaconda company is making regular shipments from the Douglas, which it is operating under lease. There are also two antimony companies making regular shipments, and several lead-zinc properties nearing the shipping stage.

JOPLIN, MO.—July 7

Associated Zinc Ore Producers is the new name for the Joplin Zinc Ore Producers. Complete reorganization recently was carried out, and as predicted, Burt W. Lyon, of Joplin, was employed as commissioner. The general plan of the association is now being worked out, and the only thing so far known is that an attempt will be made to work with the smelters rather than at swords points with them, in attempting to bring about better prices for ore. Offices have been established at Rooms 217 and 218, Miners' Bank Bldg., Joplin.

Impetus to First-Aid Work in the mines of this district was given by the first-aid field meet held at Lakeside Park, near Carterville, on the morning of July 4. Seventeen teams with a total of more than 100 miners competed, the prize going to the team from the Queen Esther mine, which will represent the district in the national first-aid field meet to be held later in the year. Fully 10,000 persons witnessed the meet and the physicians who acted as judges were generous in their praise of the skill of the contestants. The teams were drilled and the entire meet planned under the management of Dr. W. A. Lynott.

Increased Cost of Mine Supplies in this district amounts to 95%, according to the estimate made by W. B. Shackelford, president of the local operators' association. The comparison is between prices in May, 1914, and those of May, this year. In one article, carbide, the increase is only 10%, but in some the increase is as much as 300%, and the average is estimated at 95%. The figures have been sent to the Government authorities at Washington in the hope that they will be considered in fixing prices for spelter to be bought for military purposes.

DULUTH, MINN.—July 9

Price of Iron Ore is causing mining men to complain. When compared with the pig-iron prices there is no doubt but that they have a just complaint. Iron-ore prices are usually fixed for the year and the prices are changed after contracts are made. It takes 1.85 tons of iron ore to make a ton of pig-iron. It is little wonder that the mining men feel that they are being slighted. They made their prices when pig was selling at about $30 a ton, and it has since doubled in price, but they do not receive any more for the raw product. If pig does not drop in price before the first of next year, the iron-ore operators will be asking a much higher price for 1918 delivery.

WASHINGTON—July 9

Russian Mining Industry has been reported upon by Charles Janin, of San Francisco, one of the consulting engineers of the U. S. Bureau of Mines. He conferred last week with Director Manning on his return from a five-months' professional visit to the new republic. During his stay in Russia Mr. Janin acquainted himself intimately with mining conditions in both European and Asiatic Russia. While it is hard to understand in America, Mr. Janin said, there is a scarcity of labor in Russia which is interfering importantly with mining operations. At some of the mines it has been permitted to use Austrian prisoners. This arrangement has resulted satisfactorily, and the Austrians were more than pleased to have this opportunity to earn wages. In addition to labor shortage, the difficulties of securing mechanical supplies have resulted in the great falling-off in the activities in the platinum-producing region. Most of the dredges are out of commission, due to the impossibility of securing repair parts, Mr. Janin reports. The provisional government, spurred by the most urgent necessity, is taking what promises to be effective steps toward increasing mineral production. Prices have been advanced to make up for the depreciation of the ruble. There is talk of importing Mongol labor.

CANYON CITY, ORE.—July 5

Chromite Mining in Grant County has become an active industry in this section of Oregon during the last year. In May, 1916, Charles McCorkle and E. Beggs located claims on Canyon Mountain, a few miles southeast of Canyon City; these locations afterward became known as the "Big Deposit"; during the summer of 1916, the claims were leased to the Farish company, of Oakland, Calif. This company operated the deposit for a time in the fall and winter, and transferred their lease to the Zenith Chrome Mining Co., also of Oakland, which operated the deposit continuously until the spring break-up of the roads. These companies shipped about 1000 tons and mined about 1000 tons more; it is estimated that there will be at least 10,000 tons taken from this deposit. The Zenith company is also operating a deposit, known as the Ward; it is situated about five miles east of Canyon City and has the appearance of being a good-sized deposit. A number of small deposits were found and worked out during the fall and winter of 1916. This summer, C. W. Brown and I. B. Hazeltine are working a deposit situated about 20 miles west of Canyon City; the ore is hauled to Prairie City for shipment. Dan Powers is working a deposit near the Ward mine; about two miles West of Canyon City, three or four deposits are being opened and one of them, the McIntyre, is shipping. New deposits are being found almost weekly. A local company, headed by F. W. Peet, of Prairie City, is operating most of the properties, aside from the large group held by the Zenith company.

CALUMET, MICH.—July 5

June Production of Copper in this camp was below normal by 15 to 20%, because of labor shortage. There are practically enough miners here but trammers are scarce and many miners have had to go on tramming work. This has caused many of the miners to leave the camp. Now, with more labor coming in, the miners can go back to their usual work. Many experienced men are returning from the strike-infested camps in Arizona and Montana. No labor trouble is feared here, as the men remember the disastrous results of the Western Federation strike in 1913-14, and are not disposed to listen to the I. W. W. agitators who precipitated a similar unsuccessful strike on the Mesabi iron range last year.

TORONTO—July 7

Danger of Strike at Cobalt is now believed to have been averted. Following the course taken by the mine operators of Porcupine, the Cobalt mine managers have received committees of their own employees and discussed the wage question. The men were principally anxious as to the permanency of the bonuses now being paid instead of a wage increase, and were generally met with the assurance that the bonus will be continued so long as the cost of living remains abnormally high and the price of silver continues at a level where the company can afford the extra outlay. The miners generally appear to be satisfied with the position taken by the managers.

Calgary Oil Field, which has attracted but little outside attention since the subsidence of the boom of a few years ago, is being steadily developed and increasing its production. Since the first development in 1914, about 200,000 gal. of oil, principally high-grade gasoline, have been shipped from Okotoks station on the Canadian Pacific Ry., a significant feature being that the larger amount of the shipments were made during the present year. With installation of modern machinery and the drilling of new wells, a considerable increase in the output is anticipated.

Ottawa Mint Increased to refine the large quantities of gold coming from England, South Africa and Russia. According to a recent statement by Sir Thomas White, Canadian Finance Minister, the Canadian mint has been increased in capacity until it has "now the greatest capacity of any gold refinery in the world," being capable of handling 200,000 oz. or $5,000,000 per week with the chlorine process.

The Mining News

ALASKA

ALASKA GASTINEAU (Thane)—Milled in June 202,490 tons assaying $1.10; extraction, 81.25%; tailings, 20.66c. In May, milled 227,900 tons, averaging $1.19 per ton.

ALASKA JUNEAU (Juneau)—One unit of new mill started Mar. 31 and additional units in April. Total crushing for April was 7046 tons, averaging 72.6c. gold per ton. In May crushed 37,000 tons, averaging 77c. per ton. First 20 days of June, 33,229 tons were crushed. These figures announced by Pres. F. W. Bradley in statement to "Boston News Bureau." Expects to have mill in full operation by end of year. The 12 ball-mill units originally designed to have capacity of 700 tons each, but it is planned to push these units to 1000 tons, making total daily output about 11,000 tons. Anticipates recovery of 80c. per ton at working cost of 40 to 45c. per ton.

ARIZONA

Cochise County

STRIKE SITUATION in Bisbee is improving; about 60 to 70% of men working and output increasing.

Gila County

STRIKE SITUATION in Globe and Miami has not changed much. No violence at the properties, but Austrians and Serbs are reported to have had battle in streets of Globe, at least three combatants being wounded before Federal cavalrymen restored order. Power plants for pumping and lighting being operated, but no mining being done. Federal Mediator Meyers expected to arrive in district.

Greenlee County

STRIKE SITUATION unchanged in Clifton-Morenci district. Mines idle.

MIAMI (Miami)—June copper production, 5,439,000 lb., comparing with 5,112,000 for May.

INSPIRATION (Miami)—June copper production, 11,150,000 lb., comparing with 11,900,000 lb. for May.

Mohave County

UNITED EASTERN (Oatman)—Initial dividend, 5c. per share, declared payable July 30. Mill began operation in January.

Pima County

MAGGIE (Twin Buttes)—Recently bonded by owner William Reid to Eastern man.

SAN XAVIER EXTENSION (Twin Buttes)—Encountered high-grade zinc ore at 150-ft. level. Shaft down to 200 level and crosscutting for ore.

AJO CONSOLIDATED (Ajo)—Three diamond drills operating. Shipping regularly to Copper Queen smeltery at Douglas.

Yavapai County

LABOR SITUATION in Jerome is again disturbed. New demands, similar to those at Globe, are expected. [Dispatches, July 10, state that I. W. W.'s called a strike and on Sunday all properties except United Verde, United Verde Extension and Calumet & Jerome were shut down. However, work was resumed again Sunday night. On Tuesday, 67 I. W. W. agitators were deported in a train of cattle cars over the narrow-gage line. They were given plenty of drinking water but nothing to eat. Destination was Jerome Junction, 27 miles away, and 50 armed citizens accompanied them to see that they did not come back.—Editor.]

UNITED VERDE (Jerome)—Will electrify entire plant at mine. Present steam plant will be discarded probably by September. Approximately 2000 hp. will be required to handle operations, including steam shovel and other extensions planned to bring production up to 10,000,000 lb. monthly.

ARKANSAS & ARIZONA (Jerome)—Only three days drilling was done from the south drift. Drill set up in east crosscut and a flat hole is being drilled eastward. Reason for change not announced. Drifting southward resumed.

JEROME VERDE (Jerome)—Nothing has been found by diamond drilling since original discovery. Last hole was pointed eastward from drift north of the United Verde Extension. Another hole being drilled pointed west, about 300 ft. north of the original discovery. Men still cleaning out old drifts and crosscuts on the 150- and 200-ft. levels from the Columbia shaft.

CALIFORNIA

Amador County

CENTRAL EUREKA (Sutter Creek)—Development of good ore at 3350-ft. point proved wisdom of deepening shaft from 3300 level. Ore found in both north and south crosscut. Repair of tailing dam and flume nearing completion.

Butte County

ST. FRANCIS (Forbestown)—Hydroelectric plant and 50-ton Joshua Hendy ball mill contemplated. Property has been developing for several years and operating small mill. A 4-ft. vein recently disclosed is said to be proving good ore.

Eldorado County

CHROME AND MANGANESE ores for shipment to Eastern steel mills are being sought by F. W. Johnstone, of the Johnstone Engineering Co., of San Francisco, and Harry Stain, of Placerville.

Nevada County

GOODWIN (You Bet)—Reported acquired by company composed of Austrians. Owners contemplate construction of dam and adopting hydraulic methods successful in early days when Chinese leasers took out large amounts of gold.

QUAKER HILL-BLUE LEAD (37 Wall St., New York)—These gravel properties in the Colfax quadrangle, optioned by H. R. Berry, of New York, who will have associated with him D. J. McFall, of Nevada City, and H. L. Englebright.

GRASS VALLEY CONSOLIDATED (Grass Valley)—Company acquired Benoit tract of 168 acres adjoining the Allison Ranch mine, which is being unwatered. Permitted to sell additional 50,000 shares capital stock at par $1, to be used in purchase of additional ground.

Placer County

CHROME ORE mined in the Pilot Hill district is being shipped direct to Chicago by Donnelly & Neilsen, of Folsom and Hathaway & Adams, of Fairoaks. Recent development disclosed large deposit and additional men have been employed. Folsom is the railroad shipping point for Pilot Hill and other chrome-mining districts in this region; chrome-ore shipments to date amount to about 6600 tons.

Plumas County

PLACER GROUND, near Cleghorn bar, on middle fork of Feather River, will be developed by Oakland men under management of George C. Richards, of Quincy.

MANGANESE property near Indian Falls owned by Mason and Braito, reported leased by Noble Electric Steel Co. Mine to be operated and ore shipped to Heroult, Shasta County, for treatment in electric furnaces. Stated that company will construct a 700-ft. tramway and employ 30 men in mine.

CHROME deposits at Claremont, south of Quincy, are being developed by G. Maxwell, representing San Francisco men, who have optioned the property which was discovered by Thomas McCarthy. Trail to the deposit, blocked during winter and spring with 5 to 10 ft. of snow, has been shoveled out and the roads are being made ready for hauling by motor trucks to Western Pacific Ry.

Sacramento County

NATOMAS NO. 5 (Natoma)—New wooden hull launched and work of installing machinery from the old boat and such new machinery as necessary, in progress. Dredge was sunk and righted and repaired about 4 yr. ago. Its field is the Rebel Hill district, which contains large areas of cemented gravel that requires strong dredge equipment to handle. Rebuilt dredge will be stronger than the old one and hull is larger.

Shasta County

MAMMOTH COPPER MINING (Kennett)—Estimated June copper output 1,800,000 lb., comparing with 2,000,000 lb. for May. Has optioned nine claims adjoining the Stowell in Flat Creek district. Property owned by G. A. Grotefend, of Redding.

REID (Old Diggings)—Labor strike settled by Superintendent Sallee, who raised pay of miners to $3.75 and muckers to $3.25 a day. Shifts of surface men reduced from 9 to 8 hours.

Sierra County

TIGHTNER (Alleghany)—Final payment on purchase price made to H. L. Johnson, and substantial dividend declared.

BUCKINGHAM (Downieville) — Two-stamp mill being erected to crush rich free-gold quartz developed last year. T. and Z. Buckingham, owners.

MONARCH (Sierra City)—Pushing lower tunnel from Black's Canyon to tap vein at depth. A still lower tunnel will be run later. Under option to R. G. Gillespie, of Pittsburgh, Penn.

WIDE AWAKE (Downieville)—Gravel yielding well in coarse, well-worn gold. Driving main tunnel to tap channel deep in hill. Under option to Thomas Wilson.

SHAMROCK GROUP (Sierra City)—Will install electric plant. Buildings erected and tunnel to be driven to cut main vein. Bonded to Sierra Mining Corporation. John V. Powers in charge.

Siskiyou County

MANGANESE deposits being prospected in Salmon River district by San Francisco and Denver men. Several deposits are said to have been favorably developed. Samples are exhibited at the Yreka chamber of commerce.

KNOW-NOTHING (Etna) — Reported that property in Salmon River district optioned by W. R. Beall, who will immediately install a compressor. The 8-stamp mill is being remodeled. Expected the mine and mill will be in operation in August.

COLORADO

Boulder County

GOLD DISCOVERY on extension of Columbia vein, at Left Hand. Ore in 30-ft. shaft assays $20 to $50 per ton.

HURON (Boulder)—Taken under lease and bond by Du Pont-Wooding Co., of Denver.

WISCONSIN (Sugar Loaf)—Will be reopened. H. R. Moldenhauer, manager.

VASCO (Tungsten)—Thirteen leases being actively developed and operated. Mill working at full capacity. Grade of ore ranges from 3 to 50%, averaging about 10%. T. G. McGrath resigned recently as mill superintendent; succeeded by Fred Barrett. New compressor plant installed to supply air to lessees. Sampling operations in charge of F. B. Copeland, formerly of Cripple Creek.

SWARTHMORE (Eldora)—Leased to Consolidated Leasing Co. Small mill will be erected at Eldora. C. E. Kahler, manager.

Chaffee County

LINCOLN HIGHWAY (Granite)—Mine plant will be installed and work started with crew of Cripple Creek miners, soon as road is completed to property in Twin Lakes district.

EDDINGTON (Westcliffe)—Group on Texas Creek sold; mine plant to be installed. Five cars ore from surface workings ready to ship.

STEVENS (Rosita)—Being unwatered by Passiflora company.

Clear Creek County

LAKE (Idaho Springs)—Lessees shipping two cars per week.

DENBEIGH SILVER AND LEAD CO. (Silver Plume)—Operating Terrible mine; has installed compressor; electric power to be used.

JACKSON MILL (Idaho Springs)—New machinery being installed.

LAMARTINE (Idaho Springs)—Test lot of 100 tons shipped to Hudson mill. Large dump will be treated at mill on property.

Dolores County

RICO-ARGENTINE (Rico) — Regular shipments 25 tons daily being made; will be increased soon. Block leased to Marmatite company; now working 20 men.

RICO-WELLINGTON (Rico) — Lead-zinc sulphides and lead carbonates opened in two parallel beds. Rico oreshoots make along nearly vertical fissures and horizontally in limestone at contact under black shale.

Gilpin County

SUB-TREASURY (Central City)—Operated by lessees. Shipments of milling and smelting-grade ore being made from 950-ft. level. Heavy water flow interferes with development work.

EUREKA (Central City)—Shaft sinking and development work on 600-ft. level progressing with satisfactory results. Lost vein of McAllister stope recovered on 600-ft. level and shows shipping-grade ore. Remodeling of mill advancing rapidly.

MARTIN (Central City)—New shaft house built; shaft sinking to be continued; now 200 ft. deep; developing at that level.

EVERGREEN (Apex)—Mill being enlarged to 100 tons daily capacity. Equipment will consist of 175-ton ore bin, crusher, elevator, bin, Marcy mill, Dorr classifier and thickener, flotation machines, Card tables. Electric power to be used; electric pump will be installed on 350-ft. level. Exploration at depth will be done with diamond drill before further sinking. Ore consists of copper sulphides disseminated irregularly through monzonite.

Lake County

IBEX (Leadville)—New leasing policy proving beneficial to company; one lessee already shipping. Company has much unprospected ground. Denver & Rio Grande track to Ibex has been broad-gaged on account of increased tonnage shipped from Breece Hill.

San Juan County

EMPIRE STATE (Eureka)—Work resumed in the main tunnel by Akers & Kunz. Now in 400 ft. Several small veins cut, showing stringers of copper-lead ore.

LINWOOD (Eureka)—Owned by W. C. Wuertz, who has arranged to reopen. Veins containing zinc, copper and lead ore disclosed by previous development.

Summit County

ST. JOHN (Montezuma)—Additional machinery to be installed. Considerable ore ready to ship, but road conditions will not permit. Late spring has greatly delayed work in district.

WASHINGTON PLACER (Breckenridge)—First cleanup made at this hydraulic mine; results satisfactory and additional equipment to be installed.

EXCELSIOR (Frisco)—New machinery will be installed in milling plant and mine reopened.

PROGRESS (Robinson)—Mill will be reopened soon.

MICHIGAN (Kokomo)—Two cars shipped daily to Globe smeltery, Denver, and 10 cars lead ore monthly to Arkansas Valley smeltery, Leadville.

Teller County

CORIOLANUS (Cripple Creek)—Lessees have commenced making shipments. Mine owned by Aloah Gold Mining Co.

LAURA LEE (Cripple Creek)—Will be reopened by leasing company.

MILLASIER MINING CORPORATION (Cripple Creek)—Clyde shaft unwatered and 900-ft. station being retimbered. Shaft will be sunk 500 ft. deeper.

JERRY JOHNSON (Cripple Creek)—Downward extension of rich Caley oreshoot opened on 600-ft. level has been cut in raise from 950-ft. level by Cripple Creek Deep Leasing Co.

MODOC (Victor)—New 3-compartment Frankenberg shaft connected with 11th level of old Modoc incline; timbering in progress. Merrold & Co., leasing above the fifth level, developing payable ore.

MARY McKINNEY (Anaconda)—Lessees developing Gold Hill properties have opened considerable milling ore. Howard shaft in operation.

GRANITE (Victor)—Aërial tram being installed to transport ore from Dillon shaft to loading terminal near Victor depot.

IDAHO

Shoshone County

SHERMAN DEVELOPMENT (Burke)—About 3 ft. of shipping ore encountered in drift at depth of 900 ft. Property formerly known as the Union. Plan to develop to further depth of 700 ft. through old Hidden Treasure tunnel. Preparing to ship ore, mile haul to railroad.

TARBOX (Saltese, Mont.)—Main office in Wallace, Idaho, announces order placed for 150-ton mill. Lead-zinc ore developed on 600 level and shaft now being sunk to 800. Building flume for water power.

NORTHERN LIGHT (Kellogg)—Will build 150-ton mill this summer on Pine Creek. Lead-zinc ore in main vein on 400 level, proved by raise 50 ft. and winze 100 ft. Two parallel veins show ore on 200 and 400.

GIANT LEDGE (Murray)—Will build 150-ton mill this summer. Crosscut from 400-ft. shaft cut body milling lead ore 25 ft wide, which has been drifted upon 50 ft. Same shoot developed on 200 level. Property originally known as the Granite and Allie and was developed to limited extent as a gold mine. Changed to lead at depth of 160 ft., but ore still carries from $5 to $10 in gold.

HECLA (Burke)—Began shipping product to Bunker Hill smeltery, June 25, although contract does not begin until July 1. Shipments diverted because of strike at International smeltery in Utah.

MICHIGAN

Copper

CALUMET & HECLA (Calumet)—Estimated copper production for June was not off over 5 to 8%. Tonnage sent to mills was slightly richer, and leaching and regrinding plants have been increasing their output.

HANCOCK CONSOLIDATED (Hancock)—Showed slight increase in output last month. Sent to the mills, roughly, 36,000 tons of rock, 16,500 from Hancock shaft and remainder from Quincy No. 7. Mechanical tramming helped maintain output despite labor shortage.

OSCEOLA CONSOLIDATED (Osceola)—June production was 99,500 tons, compared with 107,700 tons in May. Deficit was from Kearsarge shafts.

SOUTH LAKE (Houghton)—June production, 5400 tons, against 4700 in May. Ore carrying about 15 lb. of copper per ton.

FRANKLIN (Franklin)—June output was 24,200 tons, compared with 25,300 in May. July output expected to reach nearly 30,000 tons.

AHMEEK (Ahmeek)—Output in June was 110,700 tons, against 113,000 in May. Tonnage now about 4400 daily.

MASS (Mass)—Production in June was 20,700 tons, against 22,000 in May. Finding some good ore in Evergreen lode, but greater tonnage comes from the Butler.

WINONA (Winona)—Expects to sink King Phillip No. 1 shaft deeper; copper content improving.

LA SALLE (Calumet)—Last month made a slight increase over May output, 15,400 tons of rock, against 14,800 tons.

Iron

HUNGERFORD (Humboldt)—Williams Iron Co. organized in Detroit to open this property. Shaft put down 90 ft. some years ago. Reported that a deposit of hard ore exists. Exact extent of vein is not known. Water will be pumped out. No mines in Humboldt district now working.

MISSOURI

Joplin District

MERRILL (Kansas City)—Started construction on one 400-ton mill and will build second on 120-acre lease one mile east of Picher, Okla. One shaft under way. Ore at 127 to 270 ft. Power house to be constructed in center of lease; several small compressors will be used. W. E. Merrill, of Kansas City, president.

THURMAN (Joplin)—Will build mill on lease of Porter land, near Century, Okla. New shaft down to 144 ft.; drifting with face 20 ft. high in ore. A. W. Thurman, of Joplin, James Luke and Byron Ash, Carthage, Mo., owners.

ROANOKE (Tar River, Okla.)—Starting shaft on lease west of Tar River, and will build mill. Ore from 215 to 335 ft. John T. Taylor, manager.

TRUSTEE (Joplin)—Sinking shaft to 300 ft. on lease west of Picher, Okla., to get water. New mill in operation. D. A. McCallum, Joplin, manager.

LUCKY SIX (Springfield)—Has mine near Diggins, 30 miles from Springfield; erecting mill.

PATHFINDER (Miami, Okla.)—To erect new mill on lease near camp of St. Louis, Okla. Twenty drill holes put down. Adam Scott and George Glade, of Joplin, owners.

GEORGETTE (Wentworth, Mo.)—Has developed into one of best mines Newton County ever had. Making nearly a car of good-grade concentrates daily, from 80 ft. level. Owned by Fred Kincannon, O. B. Henry and associates, of Granby.

MALCONA (Joplin) — Building 150-ton mill on Johnson land, north of Chitwood in Joplin camp. Ground operated two years by Cooper & Peters but ore has been custom milled. Third shaft being sunk. Ore at 180 ft.

MONTANA

Silver Bow County

EAST BUTTE (Butte)—June production was 1,519,240 lb. copper; 44,621 oz. silver. May production was 2,008,060 lb. copper; 59,345 oz. silver.

NORTH BUTTE (Butte)—Settlements with about 40 widows of miners killed made at cost of $3280 each. Estimated total damages for deaths will not exceed $300,000.

Lewis and Clark County

BARNES KING DEVELOPMENT CO. (Butte)—Report for second quarter expected to show cash balance in treasury of $200,000. Balance due on the Shannon will be reduced to $60,000.

NEVADA

Esmeralda County

SANDSTORM-KENDALL (Goldfield)—Exploring ground below old lease workings, where raise has been put up from 300-ft. level; intermediate drift is being run.

SPEARHEAD (Goldfield) — Developing contact at 910-ft. level by north and east drifts. East drift now in leased ground of Blue Bell company.

Nye County

TONOPAH ORE PRODUCTION, for week ended June 30, was 9283 tons, valued $162,452, comparing with 9262 tons for the previous week. Producers were: Tonopah Belmont, 2883 tons; Tonopah Mining, 1800; Tonopah Extension, 2380; Jim Butler, 850; West End, 930; Rescue, 190; Montana, 150; and Midway 100 tons.

TONOPAH EXTENSION (Tonopah)—May operating profits were $25,381; receipts, $106,545; expenses, $81,164.

MANHATTAN CONSOLIDATED (Manhattan)—Drift started west from point where ore shoot was struck on the 300 level. Additional work in driving of east drift has proven the continuity of ore.

UNION AMALGAMATED (Manhattan) Pierce fissure encountered in east drift, 390 ft. from shaft. East from this fissure, hard limestone changing to lime shale.

TONOPAH MINING (Tonopah) — In May, milled 8830 dry tons, yielding $162,000, or $19.55 per ton. Net profit, $84,255.

TONOPAH BELMONT (Tonopah)—Milled in May 12,356 dry tons, yielding 2123 oz. of gold bullion and 208,031 oz. of silver bullion. Net profit, $98,526.

NEW MEXICO

Grant County

CARLISLE (Steeplerock)—Plans being made to sink from 650-ft. to 1000-ft. level. W. Murray Saunders, manager.

JIM CROW (Duncan, Ariz.)—Preparing to sink to lower orebodies; additional machinery ordered, including hoist, electric pump, etc. H. M. Lindsey, manager.

RIVAL MINING CO. (Duncan, Ariz.)—Has retimbered the New Strike shaft and will sink. Building new wagon road to Wampoo camp. H. M. Ziesemer, manager.

SOUTH DAKOTA

Lawrence County

ORO HONDO (Deadwood)—Operations temporarily suspended until new equipment is installed. Shaft will then be sunk below present depth of 2200 ft.

TROJAN (Trojan)—Enlargement of cyanide plant being pushed; expect to treat 600 tons daily by autumn.

BALD MOUNTAIN MINES granted employees additional 50c. per day, making lowest wage for underground employees $3.50 for 8 hours.

MONTEZUMA AND WHIZZERS (Deadwood)—J. T. Millikin, of St. Louis, who has three-year option has started diamond drilling.

Pennington County

HOMELODE (Silver City)—Amalgamation-concentration plant in operation on pyritic gold ores.

AMERICAN TUNGSTEN (Hill City)—Treatment of tin ore from 200- and 300-ft. levels of Cowboy mine, continues. Incline shaft will be continued.

TEXAS

Culberson County

MINERAL MILLING CO. (Van Horn)—Shipping copper-silver ore from old Hazel mines. Tests show dump ore amenable to flotation; financing of mill being arranged. Henry M. Sutton, president; Walter L. Steele, general manager; Oliver W. Steele, assistant manager; Fred W. Schneider, superintendent of mines.

UTAH

Beaver County

PALOMA (Milford)—Strike of lead-silver ore on 900 level reported.

CROFF (Milford)—Two cars shipped and third being prepared for shipment.

Emery County

MANGANESE ORE, 10 miles from Floy, a station on the Denver & Rio Grande R.R., 15 miles from Green River, is being mined by Col. James A. Shinn and Albert Hahnewald, of Denver. Deposits formerly operated under lease by Colorado Fuel and Iron Co. Present shipments, four or five cars per week, going to Pittsburgh. Output limited by wagon haul; may install trucks. Headquarters now at Green River, Utah.

Salt Lake County

MONTANA-BINGHAM CONSOLIDATED (Bingham)—On 1000 level of Fortuna reported to have opened copper ore. Montana-Bingham tunnel being advanced to open Fortuna ground at depth. Flotation mill on Fortuna treating 100 tons daily and capacity to be increased. Tiawaukee portion of ground also being developed.

BOSTON DEVELOPMENT (Salt Lake)—Work to be resumed at old Maxfield mine in Big Cottonwood Canyon.

CARDIFF (Salt Lake)—Four trucks hauling ore; may add two more. Sending down 80 tons of ore daily.

PRINCE OF WALES (Salt Lake)—Lessees making shipment of high-grade silver-lead ore, accumulated during winter and spring. Optioned to Alta Tunnel and Transportation Co., which is driving for this vein below 1400 level.

Summit County

PARK CITY SHIPMENTS for June amounted to 6895 tons and for the first half of 1917 were 42,925 tons. There were 17 shippers; heaviest were Silver King Coalition, Judge Mining and Smelting, and Silver King Consolidated, in order named.

IOWA COPPER (Park City)—Ore opened in several places; about 200 tons accumulated for shipment.

THREE KINGS (Park City)—Drift from level 140 ft. below main level passing into ground which is showing mineralization.

Tooele County

IN DUGWAY DISTRICT, 35 miles southeasterly from Deep Creek, several Salt Lake companies are hauling ore 55 miles to Faust Station for shipment to Salt Lake. Some of the properties are the Metallic Hill, the Golconda (both lead-silver), the Dugway Silver Bell, the Canon, the Laurel, the Piedmont, etc. The Bertha is reported to have opened ore of good grade.

UTAH QUEEN (Stockton)—Considerable ore reported accumulated. Teams difficult to obtain.

CANADA

Ontario

LITTLE NIPISSING (Cobalt)—Vein, 4 in. wide, carrying native silver, has been found in winze sunk from 200-ft. level, at depth of 50 ft. Drifting on vein.

LA ROSE CONSOLIDATED (Cobalt)—Operations begun on Violet property, east of the O'Brien mine. Shaft will be put down to 300-ft. level to explore for some of the O'Brien veins.

HOLLINGER-CONSOLIDATED (Timmins)—New vein carrying free gold cut on 425-ft. level of No. 10 shaft.

HARGRAVE (Cobalt)—Preliminary returns from shipment of 12 tons high-grade ore to Deloro give aggregate recovery of about 31,000 oz. of silver.

LAKE SHORE (Kirkland Lake)—Drift on new vein at 200-ft. level is now 270 ft.; 130 ft. is in high-grade ore; for over 100 ft. vein averaged $40 over width of 4 ft. Vein shows milling ore for width of 40 ft. at present face of drift.

TECK HUGHES (Kirkland Lake)—In May treated 1295 tons, averaging $7.50.

WEST DOME (Porcupine)—Official report estimates 70,000 tons of $9 ore developed to date.

MINAKER (Kirkland Lake)—Two test pits being sunk on the vein; improving with depth.

DOME EXTENSION (South Porcupine)—Exploration work is being systematically undertaken. Drilling operations from 600-ft. level, reached by long drift from the Dome workings, have given variable results. Now proposed to drive inclined hole to depth of 1600 ft.

WASAPIKA (West Shining Tree)—Preliminary exploration completed; development will be begun with George R. Rogers, president and general manager, in charge. Sampled for approximately 2000 ft. in length. Property formerly known as Ribble gold group.

SHAMROCK (Cobalt)—Following recent visit of J. C. Hammond, president of company, and party of New York men, expenditure of $100,000 projected. New shaft to lower contact planned.

BRITISH AMERICA NICKEL CORPORATION (Sudbury)—Original plans for reduction works to be erected near the Murray mine altered to increase capacity to 2500 tons of ore per day. Development being actively pushed. The inclined shaft 700 ft. deep is being connected up with the orebodies and will be continued to the 1000-ft. level; diamond drilling is being carried on to locate another shaft. Machine shop being erected for which equipment is now on ground. Force of 150 men at work; 60 in mine; force will shortly be increased to about 225. Definitely decided to build refinery near mine; negotiating with provincial hydro-electric commission, through municipal authorities of Sudbury, for supply of 15,000 hp. of electricity. General Manager E. P. Mathewson states that recent explorations have considerably increased ore reserves, estimated at 3,000,000 tons for Murray mine and 5,000,000 tons for company's other properties. Diamond drilling has also shown occurrence at 950-ft. level that is estimated at an additional 5,000,000 tons. Norwegian nickel interests have joined in the enterprise.

BENBOW (Matheson Township)—Discovery of narrow surface vein carrying free gold reported on these claims; about one mile southeast of the Croesus.

MEXICO

STRIKE AT CANANEA unchanged. Mines and works idle.

MOCTEZUMA (Nacozari, Son.)—Working eight-hour night shift again, presumably under Government approval. Night shift was discontinued when new law, providing seven-hour night shift, became effective; resulted in laying off about 400 men. Governor Calles, recently inaugurated, is anxious to promote industrial activity, and requested resumption.

FRESNILLO (Fresnillo, Zacatecas)—Will soon resume operations.

SOMBRERETE MINING CO. (Sombrerete, Zacatecas)—Shipping ore from mine and stockpiles to the Torreon smeltery.

CIA. METALURGICA MEXICANA (San Luis Potosi)—Preparing for resumption of smelting; receiving coke and other supplies.

TEZUITLAN COPPER (Aire Libre, Puebla)—Sending in coke from Rosita and materials necessary for resumption of smelting operations.

The Market Report

Metal Markets

SILVER AND STERLING EXCHANGE

July	Sterling Exchange	Silver New York, Cents	Silver London, Pence	July	Sterling, Exchange	Silver New York, Cents	Silver London, Pence
5	4.7540	78⅛	39⅛	9	4.7550	78⅛	39 11/16
6	4.7544	78⅜	39 3/16	10	4.7555	79¼	40 5/16
7	4.7550	78¼	39⅛	11	4.7555	80	40⅜

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London quotations are in pence per troy ounce of sterling silver, 925 fine.

DAILY PRICES OF METALS IN NEW YORK

July	Copper Electrolytic	Tin Spot.	Lead N. Y.	Lead St. L.	Zinc St. L.
	28⅛				8⅛
5	@29⅛	62¼	11	10.90	@8⅜
	28⅛				8⅛
6	@29⅛	62¼	11	10.90	@8⅜
	28⅛				8⅛
7	@29⅛	62¼	11	10.90	@8⅜
	28⅛		10.95		8.75
9	@29	62⅛	@11	10.90	@8.80
	28⅛		10.90	10.85	8⅛
10	@28⅞	63	@11	@10.90	@8⅛
	28		10.90	10.85	8⅛
11	@28⅛	62⅛	@11	@10.90	@8⅛

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for the deliveries constituting the major markets, reduced to basis of New York, cash, except where St. Louis is the normal basing point.

The quotations for electrolytic copper are for cakes; ingots and wirebars. Electrolytic copper is commonly sold on "regular terms" (r.t.), including freight to the buyer's works and is subject to a discount for cash. The difference between the price delivered and the New York cash equivalent is at present about 0.25c. on domestic business. The price of electrolytic cathodes is 0.05 to 0.10c. below that of electrolytic. Quotations for spelter are for ordinary Prime Western brands. We quote New York price at 17c. per 100 lb. above St. Louis.

Some current freight rates on metals per 100 lb. are: St. Louis-New York 17c.; St. Louis-Chicago, 6.3c.; St. Louis-Pittsburgh, 13.1 cents.

LONDON

July	Copper Standard Spot	Copper Standard 3 Mos.	Copper Electrolytic	Tin Spot	Tin 3 Mos.	Lead Spot	Zinc Spot
4	130	129½	142	242	237	30½	54
5	130	129½	142	245	239½	30½	54
6	130	129½	142	245¾	240¼	30½	54
7	...	...	...	...	...	...	...
9	130	129½	142	246	242	30½	54
10	130	129½	142	246½	242½	30½	54
11	130	129½	142	245½	242	30½	54

The above table gives the closing quotations on London Metal Exchange. All prices are in pounds sterling per ton of 2,240 lb. For convenience in comparison of London prices, in pounds sterling per 2,240 lb., with American prices in cents per pound the following approximate ratios are given, reckoning exchange at 4.80. £15 = 3.21c.; £20 = 4.29c.; £30 = 6.43c.; £40 = 8.57c.; £60 = 12.85c. Variations, £1 = 0.21⅜c.

NEW YORK—July 11, 1917

The metal markets all around were dull this week and exhibited a weaker tone. The controversy about prices and the uncertainty respecting Government policy, focusing in Washington, has had the effect of killing business. In spite of the strikes shortening production of copper and zinc, buyers have shown no interest in contracting for additional supplies.

Our Washington correspondent telegraphs us this afternoon that the metals which were added to the Food and Fuel Control Bill, now pending in the Senate, were today excluded from the substitute bill which is being prepared by the Senate's Committee on Agriculture. It is believed that this action of that Committee will be supported by the Senate if the substitute bill is caused to replace the measure that is now before the Senate.

Copper, Tin, Lead and Zinc

Copper—No business was reported by producers and the market is quoted on offers to sell. Lower prices were made from day to day, and at the close it was easy to buy August-September copper on the basis of 28¼c. cash, New York, while fourth-quarter delivery was to be had at half a cent less.

The Anaconda company is going to build at Great Falls, Mont., a copper rod and wire mill, with daily capacity for 200,000 lb. of rods and 25,000 lb. of wire. The estimated cost of the plant is $500,000.

Copper Sheets are quoted at 39@40c. per lb. for hot rolled, and 1c. higher for cold rolled. Wire is quoted at 35c. per lb., f.o.b. mill.

Tin—Very little Straits tin is immediately available; on the other hand, the demand for it was slight. In brief, the tin market was very narrow and there was but little change in price. Banka tin was quoted at about 2c. per lb. under the price for Straits.

Lead—The volume of business was relatively small. Conditions were distinctly easier as to supply, and there were transactions at figures below the price of the A. S. & R. Company.

Zinc—Sales were made right through the week at small concessions in price from day to day. At the close, future spelter was offered at 8⅜c. and near-by at 8⅛c., with reports that these prices had been shaded on actual business.

Reports of curtailment of production are now coming in. Several plants in Kansas and Oklahoma have been shut down, or are about to be, and furnaces are being put out of commission at other plants.

Zinc dust is quoted at 16@17c.

Zinc Sheets—Price of zinc sheets has not been changed. Market is still at $19 per 100 lb. f.o.b. Peru, Ill., less 8% discount.

Other Metals

Aluminum—The aluminum market continues extremely quiet. Quotations slightly lower, quick delivery being offered at 57@58c. per lb. for No. 1 ingots at New York; futures slightly lower.

Antimony—The antimony market continued dull and lifeless. Such business as was reported was at materially reduced prices. We quote spot at 16@17c., and July-August shipment from China at 14@15c. The contraction in the differential between the prices for spot and futures is noteworthy.

Bismuth—Quoted at $3.50 per lb.

Cadmium—Quoted at $1.50@1.75 per lb.

Cobalt—Quoted at $1.70 per lb.

Magnesium—Ingot is quoted at $2.50.

Nickel—Steady at 50@55c. per lb., with premium of 5c. per lb. for electrolytic.

Quicksilver—The lower prices prevailing recently interested buyers, who seem to have absorbed the spot supplies, and there is said to be no longer any California quicksilver in stock in New York. This has led to an advance in price, and we quote $100@105. Late in the week sales were made at as high as $105, and one important interest quoted that price only for quicksilver to arrive. San Francisco reports, by telegraph, $100, market excited.

Tungsten—Quoted at $2.40 per lb.

Cerium—Ferroalloy firm at $28 per lb.

Safety Lamp alloy at $40 per pound.[1]

Magnesium—Ingot metal, $2.50 per lb.; powdered, $3.90 to $4.20.[1]

Molybdenum—Metal wire at $125 per kg.[1]

[1]Quotations supplied by Foote Mineral Co., Philadelphia.

Gold, Silver and Platinum

Gold—Imports of gold in New York for the week were $6,500,000 from Ottawa, which was turned over to the Federal Reserve Bank.

Silver—This metal has advanced rapidly in London during the last week from 39⅞d. to 40⅝d. This has been owing to local and continental demands for silver coming in a poorly supplied market. The diversion to the Orient, by way of San Francisco, is still absorbing the bulk of our shipments, but it has been intimated that this diversion may subside a little later in the season. Eastern rates of exchange are not advancing on a parity with the rise in London.

Silver was quoted on July 11 in New York at 80c. per oz., the highest price recorded since 1892. Supplies are not large and demand is strong. The advance during the last month has been about five cents. It is in part due to a current scarcity in supplies, coupled with a large demand from India; in part also it is a result of the unsettled state of affairs in China.

Mexican dollars at New York, July 3, 61⅛c.; 5, 61⅛c.; 6, 61⅛c.; 7, 61⅛c.; 9, 61⅛c.; 10, 62⅛c.

Platinum—We quote this market unchanged at $102@104, although figures as high as $105 and as low as $100 were mentioned in the trade.

Palladium—Quotation is unchanged at $110@115.

Zinc and Lead Ore Markets

Platteville, Wis., July 7—Blende, basis 60% Zn, $75 for premium ore down to $70 for medium grade. Lead ore, basis 80% Pb, $120 per ton. Shipments reported for the week are 2430 tons of zinc ore, 349 tons of lead ore, and 915 tons of sulphur ore. For the year to date the figures are: 72,607 tons of zinc ore, 3298 tons of lead ore, and 14,849 tons of sulphur ore. Shipped during the week to separating plants, 3236 tons of zinc ore.

Joplin, Mo., July 7—Blende per ton, high, $79.65; basis 60% Zn, premium ore $75, medium to low $70@65; calamine per ton, basis 40% Zn, $40; average selling price, all grades of zinc, $64.56 per ton.

Lead, high, $123.50; basis 80% Pb, $120; average selling price, all grades of lead, $120.88 per ton.

Shipments the week: Blende 7186 tons, calamine 1049 tons, lead 1260 tons. Value, all ores the week, $716,960.

Each week the production in the sheet-ground area lessens, and mill after mill is closing down because they cannot be operated on 2% ore with present expenses and the current market price for blende. Some of the mills are being removed to the Oklahoma field, now a continuous string of camps from Commerce, four miles north of Miami, to the Kansas state line, with one big mine over the line and a second mill building. The larger camps, north of Commerce, are Cardin and Picher, frontier mining camps in many particulars, with Century, St. Louis and Treece pushing forward for recognition. Picher is near the Oklahoma-Kansas state line in Oklahoma and Treece is in Kansas.

Other Ores

Antimony Ore—Quoted nominally at $2.20 per unit.

Chrome Ore—Standard, 40% or over, firm at $1 per unit. Little offered.[1]

Manganese Ore—Firm and in active demand, with a further advance in price, $1.10 per unit having been paid for metallurgical ore on the spot.

Molybdenum Ore—Small transactions at $2.10@2.20 per lb. of molybdenum sulphide in concentrates assaying 90 per cent.

Monazite Sand—Guaranteed 5% thoria, firm at $65 per unit of ThO_2 per ton.[1]

Strontium Ore—Crude carbonate, 83%, 7c. per lb. for 200-mesh material. Crude sulphate, 90%, 1c. for lumps and 2c. for 200 mesh.[1]

Zirkite—The 80% ZrO_2 firm at 6c. per lb. for lumps, or 8c. for 200 mesh.[1]

[1]Quotations supplied by Foote Mineral Co., Philadelphia.

Pyrites—Spanish lump quoted at 15½c. per unit on basis of 10s. ocean freight, buyer to pay war risk, excess freight and any duty. Ocean freights are 42s. 6d. from Huelva to southern ports, two steamers having lately arrived under such charters.

Tungsten Ore—But little was done in this market, supplies having been practically exhausted. Such transactions as were reported were at unchanged prices, viz.: $22 for wolframite and $25 for sheelite. Charles Hardy reports, under date of July 10, that "the stocks in New York are probably at their lowest since the beginning of 1917 and no shipments to any extent are expected."

Iron Ore—Prices, delivered lower Lake ports are for old-range bessemer, $5.95; old-range nonbessemer, $5.20; Mesabi bessemer, $5.70 and Mesabi nonbessemer, $5.05.

Iron-ore shipments down the lakes in June totaled 9,639,991 tons, or 130,000 tons increase over those of the preceding June. On account of the light shipments in April and May, due to late breaking up of the ice, shipments to July 1 are 3,500,000 tons short of last year's record, but no serious scarcity of ore is expected.

PITTSBURGH—July 10

The iron and steel markets have grown still quieter, suffering under the combined influences of the summer season, the sold-up condition of the mills, the uncertainties as to deliveries, the extremely high prices now quoted as the market, and the belief in many quarters that within a few weeks there will be price regulation for coke, pig iron, unfinished steel and finished steel products.

While the Senate wrestles with the Food Bill with its prohibition amendments and the amendments relating to price fixing for iron, steel, cotton, etc., a movement has arisen in the steel trade looking toward the establishment of a schedule of prices by the producers themselves, somewhat on the order of the recent coal-price agreement. Meanwhile conferences continue between the steel makers and the authorities at Washington relative to prices for steel involved in Government orders. Not much progress appears to have been made but this week's conference may have tangible results.

Whatever the cause, iron and steel price advances appear practically to have ceased. Pig iron and unfinished steel are no higher than a week ago and finished steel prices, as far as they can be quoted, appear to be about the same. Scrap has weakened slightly. Frequently it is a trustworthy barometer.

The Steel Corporation's unfilled obligations decreased by 503,304 tons during June, showing that the Corporation booked about 60% as much tonnage as it shipped. The Corporation has been practically out of the market since April, but it has been forced to book some business from regular customers, while it has accepted all the Government business offered.

Pig Iron—There has been a little buying of prompt foundry and malleable at $1 above the previous maximum, but otherwise the market has become extremely dull, with little inquiry for forward deliveries of any grade and no buying of consequence. We quote: Bessemer, $56@57.50; basic, $54@55; foundry and malleable, $53@56, f.o.b. valley furnaces, 95c. higher delivered Pittsburgh.

Steel—Authorities in the trade consider the market unchanged, there having been no recent transactions of consequence, and we quote billets at $95@100 and sheet bars at $105@110.

Ferroalloys

Ferromanganese—The spot market is rather irregular, quotations ranging from $425 to $475, with not enough done to establish a level. Second half is quoted at about $425. For first half $350 was recently done but $375 is now the minimum quotation.

Coke

Connellsville—The feverish buying before Independence Day sent the market up until $16 was paid for spot furnace coke and there are rumors of slightly higher prices. Late last week the market declined but there has been no further decline this week and we quote spot furnace coke at $13@14.50, depending on what road the cars loaded belong to, with spot foundry about $1 a ton higher.

STOCK QUOTATIONS

N. Y. EXCH.†	July 10
Alaska Gold M	5½
Alaska Juneau	4
Am.Sm.& Ref.,com.	105½
Am. Sm. & Ref., pf.	113
Am. Sm. Sec., pf., A	100
Am. Sm. Sec., pf. B	94½
Am. Zinc	30½
Am. Zinc, pf	62½
Anaconda	79½
Batopilas Min	1
Bethlehem Steel	132½
Bethlehem Steel, pf.	‡120
Butte & Superior	40
Cerro de Pasco	35
Chile Cop	21½
Chino	54½
Colo.Fuel & Iron	50½
Crucible Steel	85½
Dome Mines	12
Federal M. & S.	20
Federal M. & S., pf.	45½
Great Nor., ore ctf.	32½
Greene Cananea	41
Gulf States Steel	124
Homestake	105
Inspiration Con	60½
International Nickel	40
Kennecott	44
Lackawanna Steel	92½
Miami Copper	41
Nat'l Lead, com	‡56
National Lead, pf.	‡109
Nev. Consol	23
Ontario Min	5½
Quicksilver	1½
Quicksilver, pf.	2½
Ray Con	28
Republic I.&S., com.	91½
Republic I. & S., pf	102½
Sloss-Sheffield	56½
Tennessee C. & C.	17½
U. S. Steel, com	126½
U. S. Steel, pf	118
Utah Copper	108½
Va. Iron C. & C.	68

N. Y. CURB†	July 10
Big Ledge	1⅞
Butte & N. Y.	1⅞
Butte C. & Z	10½
Caledonia	.58
Calumet & Jerome	1.43½
Can. Cop. Corpn	2½
Carlisle	4
Cashboy	.08
Con. Ariz. Sm.	2½
Con. Coppermines	5½
Con. Nev.-Utah	.08
Emma Con	‡1½
Ferber	.60
First Nat. Cop	3½
Goldfield Con	.51
Goldfield Merger	.06
Greenmonster	93½
Hecla Min	8½
Howe Sound	5½
Jerome Verde	1½
Joplin Ore & Spel	‡.15
Kerr Lake	4½
Magma	45
Majestic	‡.40
McKinley-Dar-Sa	‡.47
Mohican	.62½
Mother Lode	.27
N. Y. & Hond	‡12
Nipissing Mines	7½
Ohio Cop	1.56½
Ray Hercules	4
Rochester Mines	50
St. Joseph Lead	19
Standard S. L.	68½
Stewart	½
Success	.36
Tonopah	6½
Tonopah Ex	1.43½
Tribullion	⅛
Troy Arizona	.26
United Cop	17/
United Verde Ext	38½
United Zinc	5
Utica Mines	.24
White Knob, pf	2
White Oaks	‡2
Yukon Gold	2½

SAN FRAN.*	July 7
Alta	.04
Andes	.11
Best & Belcher	.02
Bullion	.02
Caledonia	.15
Challenge Con	.01
Confidence	.10
Con. Virginia	.33
Gould & Curry	.02
Hale & Norcross	.03
Jacket-Cr. Pt.	.08
Mexican	.12
Occidental	.65
Ophir	.10
Overman	.03
Savage	.07
Seg Belcher	.02
Sierra Nevada	.16
Union Con	.20
Utah Con	.01
Belmont	4.00
Jim Butler	.80
MacNamara	.25
Midway	.09
Mont.-Tonopah	.20
North Star	.10
Rescue Eula	.21
West End Con	‡.68
Atlanta	.10
Booth	.07
Comb. Frac	‡.04
D'field Daisy	.03
Florence	.18
Jumbo Extension	.31
Kewanas	.13
Nevada Hills	.22
Nevada Packard	.32
Round Mountain	.35
Silver Pick	.10
White Caps	1.35
Big Jim	.70
United Eastern	4.25

BOSTON EXCH.*	July 10
Adventure	2½
Ahmeek	98½
Algomah	.60
Allouez	62
Ariz. Com., ctfs	13
Arnold	.30
Bonanza	.20
Butte-Balaklava	.58
Calumet & Ariz	77½
Calumet & Hecla	535
Centennial	16½
Copper Range	60½
Daly West	1
Davis-Daly	5½
East Butte	12½
Franklin	6½
Granby	82
Hancock	14
Hedley	15
Helvetia	.25
Indiana	2
Isle Royale	30
Keweenaw	2
Lake	11½
La Salle	3
Mason Valley	6½
Mass	12½
Mayflower	2½
Michigan	4½
Mohawk	81½
New Arcadian	2⅛
New Idria	14
North Butte	17
North Lake	1
Ojibway	1½
Old Dominion	57½
Osceola	85
Quincy	86
St. Mary's M. L.	78½
Santa Fe	1
Seneca Mines	10
Shannon	8
Shattuck-Ariz	24½
So. Lake	3½
So. Utah	.20
Superior	⅞
Superior & Bost	4½
Trinity	7½
Tuolumne	1
U. S. Smelting	57½
U. S. Smelt'g, pf.	49½
Utah Apex	2½
Utah Con	15½
Utah Metal	4½
Victoria	3½
Winona	3½
Wolverine	44½
Wyandot	.50

BOSTON CURB*	July 10
Alaska Mines Corp.	.70
Bingham Mines	12½
Boston Ely	.40
Boston & Mont	.53
Butte & Lon'n Dev	.14
Calaveras	3½
Calumet-Corbin	.01½
Chief Con	12½
Cortez	.20
Crown Reserve	.28
Crystal Cop	1⅛
Eagle & Blue Bell	2½
Houghton Copper	.95
Intermountain	1½
Iron Cap, Com	14½
Iron Cap Cop., pf.	14½
Mexican Metals	.28
Mines of America	1½
Mojave Tungsten	.40
Nat. Zinc & Lead	.65
Nevada-Douglas	‡1½
New Baltic	1½
New Cornelia	‡18½
Oneco	.50
Pacific Mines	.30
Rex Cons	.24

SALT LAKE*	July 10
Bannack	1.00
Big Four	.35
Black Jack	.06
Cardiff	5.50
Colorado Mining	.20
Daly-Judge	8.00
Empire Copper	1.25
Gold Chain	.16
Grand Central	.63
Grand Gulch	.19
Iron Blossom	1.00
Lower Mammoth	.03
May Day	.06½
Moscow	.12
Prince Con	1.12½
Silver-King Coal'n	3.02
Silver King Con	3.70
Sioux Con	.12
So. Hecla	1.07
Uncle Sam	.02½
Wilbert	.16
Yankee	.07½

TORONTO*	July 10
Bailey	.03
Beaver Con	.36
Buffalo Mines	1.15
Chambers Ferland	.12
Coniagas	4.30
La Rose	.40
Peterson Lake	.12
Right of Way	.05
T. & Hudson Bay	‡38.00
Temiskaming	.38
Wettlaufer-Lor	.05½
Dome Exten	.18
Dome Lake	.16
Foley O'Brien	.60
Hollinger	4.35
Jupiter	‡.28
McIntyre	1.57
Newray	.52
Porcu. Crown	.48½
Schumacher	.40
Vipond	‡.28
West Dome	.19½

STOCK QUOTATIONS—Continued

COLO. SPRINGS	July 7
Cresson Con	5.43½
Doctor Jack Pot	.04½
Elkton Con	.06
El Paso	.30
Gold Sovereign	.04
Golden Cycle	2.14½
Granite	.52
Isabella	.10
Mary McKinney	.17
Portland	1.49
United Gold M	.21
Vindicator	.72

LONDON	June 15		
Alaska Mexican	£0	10s	0d
Alaska Tre'dwell	4	5	0
Burma Corp	4	3	9
Cam & Motor	0	8	6
Camp Bird	0	7	0
El Oro	0	10	0
Esperanza	0	11	0
Mexican Mines	4	7	6
Nechi, pfd	0	11	9
Oroville	0	16	3
Santa Gert'dis.	0	10	0
Tomboy	0	19	3

* Bid prices. † Closing prices. ‡ Last Quotations.

MONTHLY AVERAGE PRICES OF METALS

Silver	New York			London		
	1915	1916	1917	1915	1916	1917
January	48.855	56.775	75.630	22.731	26.960	36.682
February	48.477	56.755	77.585	22.753	26.975	37.742
March	50.241	57.935	73.861	23.708	27.597	36.410
April	50.250	64.415	73.875	23.709	30.662	36.963
May	49.915	74.269	74.745	23.570	35.477	37.940
June	49.034	65.024	76.971	23.267	31.060	39.065
July	47.519	62.940	.....	22.597	30.000	.....
August	47.163	66.083	.....	22.780	31.498	.....
September	48.680	68.515	.....	23.591	32.584	.....
October	49.385	67.855	.....	23.925	32.361	.....
November	51.714	71.604	.....	25.094	34.192	.....
December	54.971	75.765	.....	26.373	36.410	.....
Year	49.684	65.661	.....	23.675	31.315	.....

New York quotations cents per ounce troy, fine silver; London, pence per ounce, sterling silver, 0 925 fine

Copper	New York		London			
	Electrolytic		Standard		Electrolytic	
	1916	1917	1916	1917	1916	1917
Jan	24.008	28.673	88.083	131.921	116.167	142.895
Feb	26.440	31.750	102.667	137.895	133.167	148.100
Mar	26.310	31.481	107.714	136.750	136.000	151.000
April	27.895	27.935	124.319	133.842	137.389	147.158
May	28.625	28.788	135.457	130.000	152.522	142.000
June	26.601	29.962	112.432	130.000	137.455	142.000
July	23.865	.....	95.119	.....	125.500	.....
Aug	26.120	.....	110.283	.....	126.304	.....
Sept	26.855	.....	113.905	.....	134.071	.....
Oct	27.193	.....	122.750	.....	142.523	.....
Nov	30.625	.....	134.659	.....	155.432	.....
Dec	31.890	.....	145.316	.....	162.842	.....
Year	27.202	.....	116.059	.....	138.281	.....

Tin	New York		London	
	1916	1917	1916	1917
January	41.825	44.175	175.548	185.813
February	42.717	51.420	181.107	198.974
March	50.741	54.388	193.609	207.443
April	51.230	55.910	199.736	220.171
May	49.125	63.173	196.511	245.114
June	42.231	62.053	179.466	242.083
July	38.510	.....	168.357	.....
August	38.565	.....	169.870	.....
September	38.830	.....	171.345	.....
October	41.241	.....	179.307	.....
November	44.109	.....	186.932	.....
December	42.635	.....	183.368	.....
Av year	43.480	.....	182.096	.....

Lead	New York		St Louis		London	
	1916	1917	1916	1917	1916	1917
January	5.921	7.626	5.826	7.530	31.167	30.500
February	6.246	8.636	6.164	8.595	31.988	30.500
March	7.136	9.199	7.375	9.120	34.440	30.500
April	7.630	9.288	7.655	9.158	34.368	30.500
May	7.463	10.207	7.332	10.202	32.967	30.500
June	6.936	11.171	6.749	11 123	31.011	30.500
July	6.352	.....	6.185	.....	28.137	.....
August	6.244	.....	6.088	.....	29.734	.....
September	6.810	.....	6.699	.....	30.786	.....
October	7.000	.....	6.898	.....	30.716	.....
November	7.042	.....	6.945	.....	30.500	.....
December	7.513	.....	7.405	.....	30.500	.....
Year	6.853	.....	6.777	.....	31.359	.....

Spelter	New York		St Louis		London	
	1916	1917	1916	1917	1916	1917
Jan	16.915	9.619	16.745	9.449	89.810	48.329
Feb	18.420	10.045	18.260	9.875	97.762	47.000
Mar	16.846	10.300	16.676	10.130	95.048	47.000
April	16.695	9.459	16.525	9.289	99.056	54.632
May	14.276	9.362	14.106	9.192	94.217	54.000
June	11.752	9.371	11.582	9.201	68.591	54.000
July	8.925	.....	8.755	.....	50.750	.....
Aug	8.730	.....	8.560	.....	51.587	.....
Sept	8.990	.....	8.820	.....	52.095	.....
Oct	9.829	.....	9.659	.....	54.159	.....
Nov	11.592	.....	11.422	.....	56.023	.....
Dec	10.665	.....	10.495	.....	55.842	.....
Year	12.804	.....	12.634	.....	72.071	.....

New York and St. Louis quotations, cents per pound, London, pounds sterling per long ton. ¼ Not reported.

Pig Iron, Pitts.	Bessemer‡		Basic‡		No. 2 Foundry	
	1916	1917	1916	1917	1916	1917
January	$21.60	$35.95	$18.78	$30.95	$19.70	$30.95
February	21.16	36.37	18.93	30.95	19.51	30.95
March	21.81	37.37	19.20	33.49	19.45	35.91
April	21.65	42.23	18.95	38.90	19.45	40.06
May	21.78	46.94	19.11	42.84	19.58	43.60
June	21.95	54.22	18.95	50.05	19.34	50.14
July	21.95	.....	18.95	.....	19.20	.....
August	21.95	.....	18.95	.....	19.22	.....
September	22.88	.....	19.58	.....	19.53	.....
October	24.61	.....	21.26	.....	21.51	.....
November	30.07	.....	28.18	.....	26.55	.....
December	35.16	.....	30.95	.....	30.79	.....
Year	$23.88	.....	$20.98	.....	$21.15	.....

‡ As reported by W. P. Snyder & Co.

Current Prices—Materials and Supplies

IRON AND STEEL

DRILL STEEL—New York price in cents per pound is:

Solid ..... 12 Hollow 24

In St. Louis the price of solid is 14½c.

SHEETS—Quotations are in cents per pound in various cities from warehouse, also the base quotation from mill:

Blue Annealed	Large Lots, Pittsburgh	St. Louis	Chicago	San Francisco	New York July 6, 1917	New York One Yr. Ago
No. 10	7.85	9.55	9.50	10.50	9.50	4.25
No. 12	8.10	9.60	9.55	10.55	9.55	4.30
No. 14	8.35	9.65	9.60	10.60	9.60	4.35
Black						
Nos. 18 and 20	8.05	9.15	9.30	10.80	9.80	3.45
Nos. 22 and 24	8.10	9.20	9.35	10.83	9.85	3.50
No. 26	8.15	9.25	9.40	10.88	9.90	3.55
No. 28	8.25	9.35	9.50	10.98	10.00	3.65
Galvanized						
No. 10	9.00	Premium	9.75	....	....	4.50
No. 12	9.10	Premium	9.85	12.15	....	4.50
No. 14	9.25	Premium	10.00	12.15	11.85	4.50
Nos. 18 and 20	9.40	Premium	10.15	12.45	11.65	4.80
Nos. 22 and 24	9.80	Premium	10.55	12.62	12.55	4.95
No. 26	9.95	Premium	10.20	12.77	12.70	5.10
No. 28	10.25	Premium	10.50	13.06	13.00	5.40

CORRUGATED SHEETS—Price of corrugated sheets (2½-in. corrugations) in cents per pound:

Gage		Cincinnati	Birmingham	St. Louis	Denver
18–20	Black	$18.00*	....	$0.092	
28	Black	5.75*	....	.094	$0.10
10	Galvanized	....	....	....	....
18–20	Galvanized	22.50*	$0.11	....	....
28	Galvanized	8.75*	.12	.113	.12

*Price per square of 100sq.ft.

STEEL RAILS—The following quotations are per ton f.o.b. Pittsburgh and Chicago for carload or larger lots. For less than carload lots 5c. per 100 lb. is charged extra:

	Pittsburgh July 6, 1917	Pittsburgh One Year Ago	Chicago July 6, 1917	Chicago One Year Ago
Standard bessemer rails	$38.00	$33.00	$38.00	$33.00
Standard openhearth rails	40.00	35.00	40.00	35.00
Light rails, 8 to 10 lb.	63.00	50.00	68.00	43.00
Light rails, 12 to 14 lb.	62.00	49.00	67.00	42.00
Light rails, 25 to 45 lb.	60.00	47.00	65.00	40.00

Note—Rerolled rails sell for same price as new light rails.

TRACK SUPPLIES—The following prices are base per 100 lb. f.o.b. Pittsburgh for carload lots, together with the warehouse prices at the places named:

	Pittsburgh July 6, 1917	Pittsburgh One Year Ago	Chicago	St. Louis	San Francisco
Standard railroad spikes	$4.50	$2.65	$5.00	$4.85	$5.75
Track bolts	6.25	3.25	6.25	5.05	7.50
Standard section angle bars	...	2.00	4.00	Premium	...

STRUCTURAL MATERIAL—The following are the base prices f.o.b. mill, Pittsburgh, together with the quotations per 100 lb. from warehouses at the places named:

	Pittsburgh	New York July 6, 1917	New York 1 Yr. Ago	St. Louis	Chicago	San Francisco	Dallas
Beams, 3 to 15 in.	$4.50	$5.25	$3.25	$5.05	$5.00	$7.75	$6.00
Channels, 3 to 15 in.	4.60	5.25	3.25	5.05	5.00	7.75	6.00
Angles, 3 to 6 in., ¼ in. thick	4.50	5.25	3.25	5.05	5.00	7.75	6.00
Tees, 3 in. and larger	4.50	5.30	3.30	5.05	5.00	7.75	6.00
Plates	9.00*	9.00	4.00	6.55	7.00	10.00	9.00

*Price running wild. For prompt delivery from warehouse, $12.

New York extras on other shapes and sizes per lb. are as follows:

I-beams over 15 in.	$0.10
Angles over 6 in., on one or both legs	.10
Angles, 3 in. on one or both legs less than ¼ in. thick	.70
Cutting to lengths, under 3 ft. to 2 ft. inclusive	.25
Cutting to lengths, under 2 ft. to 1 ft. inclusive	.50
Cutting to lengths, under 1 ft.	1.55

No charge is made for cutting to lengths 3 ft. and over.

HORSE AND MULE SHOES—Warehouse prices per 100 lb. in cities named:

	Cincinnati	St. Louis	Denver	Birmingham
Straight	$6.75	$5.85	$7.25	$6.50
Assorted	7.25	6.00	7.50	7.00

WIRE ROPE—Discounts from list price on regular grades of bright and galvanized are as follows:

	New York July 6, 1917	New York 1 Yr. Ago	St. Louis	Chicago
Galvanized	10—2½%	25—2½%	10—2½%	10—2½%
Bright	20—2½%	35—2½%	20—2½%	15—2½%

BAR IRON—Prices in cents per pound at the places named are as follows:

	July 6, 1917	One Year Ago
Pittsburgh, mill	4.75	2.50
Warehouse, New York	4.75	3.25
Warehouse, Cleveland	4.95	3.25
Warehouse, Chicago	4.50	3.10

SWEDISH (NORWAY) IRON—This material per 100 lb. sells as follows:

	July 6, 1917	One Year Ago
New York	$20.00 to 26.00	$6.00
Cleveland	12.30	6.30
Chicago	12.00	5.25

In coils an advance of 50c. usually is charged:
Note—Stock scarce generally.

PIPE—The following discounts are for carload lots f.o.b. Pittsburgh, in effect May 1, 1917:

BUTT WELD

Steel Inches	Black	Galvanized	Iron Inches	Black	Galvanized
⅛, ¼ and ⅜	42%	15½%	⅜ to 1½	38%	22%
½	46%	31½%			

LAP WELD

2	42%	27½%	1¼	23%	8%
2½ to 6	45%	35½%	1½	30%	16%
			2	31%	17%
			2½ to 4	33%	20%
			4½ to 6	33%	20%

BUTT WELD. EXTRA STRONG PLAIN ENDS

⅛, ¼ and ⅜	38%	20½%	⅜ to 1½	38%	23%
½	43%	30½%			
¾ to 1½	47%	34½%			

LAP WELD. EXTRA STRONG PLAIN ENDS

2	40%	28½%	1¼	24%	8%
2½ to 4	43%	31½%	1½	30%	16%
4½ to 6	42%	30½%	2	32%	19%
			2½ to 4	34%	22%
			4½ to 6	33%	21%

Note—National Tube Co. quotes on basing card dated Apr. 1.

Stock discounts in cities named are as follows:

	New York Black	New York Galvanized	Cleveland Black	Cleveland Galvanized	Chicago Black	Chicago Galvanized
¾ to 3 in. steel butt welded	38%	22%	34%	20%	43%	28%
3½ to 6 in. steel lap welded	28%	10%	38%	23%	39%	25%

Malleable fittings, Class B and C, from New York stock sell at 5 and 5% from list prices. Cast iron, standard sizes, 34 and 5%.

MISCELLANEOUS

FLOTATION OILS—Prices of oils for flotation, in cents per gallon:

	New York
Pure steam-distilled pine oil	$0.50½
Pure destructively distilled pine oil	.40
Pine tar oil	.26*
Crude turpentine	.37
Hardwood creosote	.19½*

*F.o.b. Cadillac, Mich.

SODIUM CYANIDE—New York price is 30c. per lb.

SODIUM SULPHIDE—In New York the price per pound is 3¾c. for concentrated, 1¾c. for crystals. The St. Louis price for concentrated is quoted at 6c.

ZINC DUST—New York price is 16@17c. per lb.

CALCIUM CARBIDE—Price f.o.b. cars at warehouse points east of Mississippi (except in Alabama, Georgia and Florida) is $82.50 for Cameo, $87.50 for Union. In territory between Mississippi River and the Rockies and in Alabama, Georgia and Florida, add $5; west of Rockies, add $10 to $15.

HOSE—

Fire

	50-Ft. Lengths
Underwriters' 2½- in.	60c. per ft.
Common, 2½-in.	50%

Air

	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.55	$0.30	$0.25

Steam—Discounts from list

First grade... 30% Second grade... 30-5% Third grade... 40-10%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition ..... 50–10% Best grade 25%
Standard 40%

LEATHER BELTING—Present discounts from list in the following cities are as follows:

	Medium Grade	Heavy Grade
New York	40%	35%
St. Louis	50%	40%
Chicago	40—5%	35—10%

RAWHIDE LACING—40%.

MANILA ROPE—For rope smaller than ⅝-in. the price is ½ to 2c. extra; while for quantities amounting to less than 600 ft. there is an extra charge of 1c. The number of feet per pound for the various sizes is as follows: ⅜-in., 8 ft.; ½-in., 6; ⅝-in., 4½; 1-in., 3⅓; 1¼-in., 2 ft. 10 in.; 1½-in., 2 ft. 4 in. Following is price per pound for ⅜-in. and larger, in 1200-ft. coils:

Boston	$0.32½	Kansas City	$0.31½
New York	.31¼	New Orleans	.31
Cincinnati	.29	Los Angeles	.31½
Denver	.34	St. Paul	.31½

PACKING—Below are prices each per pound in cities named:

		Asbestos St. Louis	New York	Chicago
Valve and Stuffing	Twisted plain, 25-lb. cartons	$0.80	$0.65 to 0.70	$1.00
	Twisted graphite, 25-lb. cartons	.90	.90	1.35
	Braided plain, 25-lb. cartons	.80	.80	1.20
Box	Braided graphite, 25-lb. cartons	.90	1.00	1.55

Asbestos wick in balls, ¼, ½-, 1-, 25- and 50-lb. cartons, $0.65@0.70, New York; $1, Chicago.

Rubber asbestos, compressed sheet, medium grade about $0.80, New York; $1, Chicago.

	STEAM		
Following in 25- and 50-lb. cartons:	New York	Chicago	St. Louis
First grade	$0.83	$1.10	$1.45
Second grade	.55	.85	.90
RUBBER AND DUCK			
High grade	$0.50	$0.55	$0.60
Cold water	.30	.30	.40
PISTON			
Asbestos, duck and rubber	$1.75	$2.00	....
Flax, first grade	.94	1.00	$0.90
Rubber and duck	.90	1.00	.70

RAILWAY TIES—For fair-size orders, the following prices per tie hold:

	Material	6 in. x 8 in. by 8 Ft.	7 in. x 9 in. by 8 Ft. 6 In.
New York	Yellow Pine	$1.06 to 1.11	$1.25
St. Louis	White Oak	1.00	.75
Chicago	Green	.85	.97
San Francisco	Creosoted	1.18	1.60

GREASES—Prices are as follows in the following cities in cents per pound for barrel lots:

	New York	Chicago	St. Louis
Cup	5 to 7	7½	4⅝
Fiber or sponge	5 to 7	7¾	5⅝
Transmission	5 to 7	6¼	5⅝
Axle	3 to 7	5	3 10
Gear	4 to 5	6½	3
Car journal (S. & F.)	6½ to 7	6	9½

COTTON WASTE—The following prices are in cents per pound:

	New York July 6, 1917	New York One Year Ago	Cleveland	Chicago
White	13.00 to 15.00	12.50	14.00	13.00 to 15.00
Colored mixed	10.00 to 12.00	9.00	12.00	10.00 to 12.00

WIPING CLOTHS—In Cleveland the jobbers' price per 1000 is as follows:

13¼ x 13¼ ..... $35.00 13¼ x 20½ $45.00

In Chicago they sell at $30 to $33 per 1000.

LINSEED OIL—These prices are per gallon:

	New York July 6, 1917	New York One Year Ago	Cleveland July 6, 1917	Cleveland One Year Ago	Chicago July 6, 1917	Chicago One Year Ago
Raw in barrels	$1.26	$0.71	$1.28	$0.73	$1.29	$0.73
5-gal. cans	1.36	.81	1.38	.83	1.34	.83

WHITE AND RED LEAD in 500-lb. lots sell as follows in cents per pound:

	Red July 6, 1917 Dry	Red July 6, 1917 In Oil	Red 1 Year Ago Dry	Red 1 Year Ago In Oil	White July 6, 1917 Dry and In Oil	White 1 Yr. Ago Dry and In Oil
100-lb. keg	13.25	13.50	10.50	11.00	13.00	10.50
25- and 50-lb. kegs	13.50	13.50	10.75	11.25	13.25	10.75
12½-lb. keg	13.75	14.00	11.00	11.50	13.50	11.00
1- to 5-lb. cans	15.25	15.50	12.50	12.50	15.50¼	12.50

NUTS—From warehouse at the places named, on fair-sized orders, the following amount is deducted from list:

¼	New York July 6, 1917	New York One Year Ago	Cleveland July 6, 1917	Cleveland One Year Ago	Chicago July 6, 1917	Chicago One Year Ago
Hot pressed square	List	$2.00	$1.65	$2.75	$3.00	$3.25
Hot pressed hexagon	List	2.00	1.50	3.00	3.00	3.25
Cold punched square	List	1.50	1.40	2.50	1.75	3.00
Cold punched hexagon	List	2.00	1.40	3.00	2.25	3.50

Semifinished nuts sell at the following discounts from list price:

	July 6, 1917	One Year Ago
New York	50%	50—10%
Cleveland	50%	60%
Chicago	50%	65%

MACHINE BOLTS—Warehouse discounts in the following cities:

	New York	Cleveland	Chicago
⅝ by 4 in. and smaller	30%	40%	35—5%
Larger and longer up to 1 in. by 30 in.	15%	30%	20—2½%

WROUGHT WASHERS—From warehouses at the places named the following amount isi deducted from list price:

New York ..... $5.00 Cleveland ..... $4.50 Chicago $5.00

For cast-iron washers the base price per 100 lb. is as follows:

New York ..... $2.25 Cleveland ..... $3.40 Chicago $3.25

EXPLOSIVES AND ACCESSORIES

EXPLOSIVES—Price per pound in small lots at cities named:

	Low Freezing 20%	Low Freezing 40%	Gelatin 60%	Gelatin 80%	Black Powder*	Fuse†
New York	....	$0.24½	$0.29½	....	....	....
Boston	....	....	.31¼	.35	....	....
Kansas City	$0.17	.23¼	.28¼	.34½	....	....
New Orleans	.18¼	.22¼	.27¼	....	....	....
Los Angeles	.19	.25	.31½	....	....	....
St. Paul	.17	.23¼	.28¼	.34½	....	....
St. Louis	.14¼	.20½	.25½	.31¾	$1.85	$5.80
Denver	.16	.20	.25	.33	....	....

*Price per keg. †1000 ft.

BLASTING POWDER—Price per keg:

		Delivered Carload Lots
Ohio, f.o.b. Columbus	400 kegs	$1.74½
Indiana, f.o.b. Aetna		1.79½
Indiana, f.o.b. Indianapolis		
Illinois, f.o.b. Chicago	400 kegs	
Iowa points on Mississippi River, f.o.b. St. Louis		
Iowa points on Mississippi River, f.o.b. Fond du Lac		1.82
Missouri points on Mississippi River, f.o.b. Des Moines		
Missouri points on Mississippi River, f.o.b. Saginaw		
Michigan, South Pennsula only, f.o.b. Kansas City		
Iowa points not on Mississippi River, f.o.b. Duluth	800 kegs	1.84½
Missouri points not on Mississippi Riiver	400 kegs	1.87
Wisconsin (except Counties of Ashland, Bayfield, Douglas Florence and Iron	400 kegs	1.94½
Minnesota, f.o.b. Minn. Transfer, Kansas Citiy, Omaha,	800 kegs	1.84½

Above prices are for CC, C, F, FF, FFF sizes. Price on FFFF size 5c. per keg advance over above prices.

SAFETY FUSE—Prices f.o.b. New York and Chicago, per 1000 ft., less quantity discount:

Cotton	$6.65	Beaver	$6.75
Single tape	6.85	Anchor	7.65
Double tape	7.75	Crescent	7.65
Triple tape	8.60		

BLASTING CAPS—Llist price of blasting and electric blasting caps f.o.b. shipping points in states named:

	Electric Blasting Caps, Copper Wire Price per 100 No.	4 Ft.	6 Ft.	8 Ft.	10 Ft.	Blasting Caps No.	p. 1000
New York, Ohio, Indiana, Illinois, Kentucky and South Michigan	6	$6.00	$7.00	$8.00	$9.00	5	$14.00
	8	8.00	9.00	10.00	11.00	6	17.00
						8	28.00
Missouri, Iowa, Minnesota, Wisconsin and North Michigan	6	6.10	7.11	8.12	9.13	5	14.15
	8	8.10	9.11	10.12	10.13	6	17.15
						8	28.25
Kansas, Nerbraska, North and South Dakota	6	6.15	7.16	8.17	9.18	5	14.30
	8	8.15	9.16	10.17	11.18	6	17.30
						8	28.55

CONSTRUCTION MATERIALS

ROSENDALE NATURAL CEMENT—Price to dealers for 500 bbl. or over, f.o.b., including bags:

New York $1.15

30c. allowed for bags.

BRICK—The price per 1000 in cargo or carload lots is as follows:

	Common July 6, 1917	Common One Month Ago	Common One Year Ago	Paving Brick	Paving Block
New York	$9.00 to 9.50	$10.25	$8.00	$25.00	$35.00
Chicago	8.00	8.00	6.25	16.75	24.00
Kansas City	11.00	10.00	....	....	20.00
Los Angeles	....	7.50	....	....	28.00
Denver	8.00	....	....	....	....
Cincinnati	13.50	9.50	....	....	22.50

PORTLAND CEMENT—These prices are for barrels in carload lots, including bags:

	July 6, 1917	One Month Ago	One Year Ago
New York	$2.22	$2.22	$1.72
Chicago	2.31	2.31	1.81
Pittsburgh	2.31	2.31	1.81
Cleveland	2.44	2.44	1.94
St. Louis	2.45	2.45	1.86
Denver	2.39	....	....
Los Angeles	2.40	2.40	....

LUMBER—Price per M in carload lots:

	1-In. Rough, 10 In. x 16 Ft. and Under Y.P.	Fir	Hemlock	2-In. T. and G. 10 In. x 16 Ft. Y.P.	Fir
Cincinnati	$38.00	....	....	$36.00	....
Kansas City	43.25	$44.50	$43.50	48.00	....
Denver	....	34.00	....	....	$39.00
St. Paul	....	51.00	33.50	59.00	37.50

	8 x 8-in. x 20 Ft. and Under Y.P.	Fir	Hemlock	Spruce	12 x 12-In., 20 Ft. and Under Y.P.	Fir
Cincinnati	$36.00	....	....	....	$40.00	....
Kansas City	38.00	$35.00	$35.00	....	42.50	$35.00
Denver	....	40.00	....	$36.00	....	44.00
St. Paul	....	40.00	31.50	32.00	....	45.00

ROOFING MATERIALS—Prices per ton f.o.b. New York or Chicago:

	Carload Lots	Less Than Carload Lots
Tar felt (14 lb. per square of 100 sq.ft.)	$59.00	$60.00
Tar pitch (in 400-lb. bbl.)	15.00	17.00
Asphalt pitch (in barrels)	29.00	30.50
Asphalt felt	60.00	62.00

PREPARED ROOFINGS—Standard grade rubbered surface complete with nails and cement costs per square as follows in New York and Chicago:

	1-Ply c.l.	1-Ply l.c.l.	2-Ply c.l.	2-Ply l.c.l.	3-Ply c.l.	3-Ply l.c.l.
No. 1 grade	$1.15	$1.30	$1.45	$1.60	$1.75	$1.90
No. 2 grade	1.00	1.15	1.25	1.40	1.50	1.65

Asbestos asphalt saturated felt (14 lb. per square) costs $5.35 per 100 lb.

Slate-surfaced roofing (red and green) in rolls of 108 sq.ft. costs $1.85 per roll in carload lots and $2.10 for smaller quantities.

Shingles, red and green slate finish, cost $4.75 per square in carloads, $5 in smaller quantities, in Philadelphia.